

# **Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater**

## **Volume 1: Summary Tier 1 Lookup Tables**

Prepared for:

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- TIER 2 SOIL LEACHING MODEL



# Executive Summary

This document presents Environmental Screening Levels (ESLs) for chemicals commonly found in soil and groundwater at sites where releases of hazardous chemicals have occurred. The ESLs are considered to be conservative. ESLs based on human health and ecological concerns are well below levels that would cause immediate, acute health effects. Under most circumstances, and within the limitations described, the presence of a chemical in soil, soil gas or groundwater at concentrations below the corresponding ESL can further be assumed to not pose a significant, long-term, chronic threat to human health and the environment. Additional evaluation will generally be necessary at sites where a chemical is present at concentrations above the corresponding ESL. Active remediation may or may not be required, however, depending on site-specific conditions and considerations. This document may especially be beneficial for use at sites with limited impacts, where the preparation of a more formal environmental risk assessment may not be warranted or feasible due to time and cost constraints.

The ESLs were developed to assist in the rapid identification of common environmental concerns at sites with contaminated soil and groundwater. These concerns include:

#### Surface Water and Groundwater:

- Threats to drinking water resources;
- Threats to aquatic habitats;
- Intrusion of subsurface vapors into buildings;
- Gross contamination and general resource degradation concerns;

#### Soil:

- Direct-exposure and threats to human health;
- Intrusion of subsurface vapors into buildings;
- Leaching and subsequent impacts to groundwater resources;
- Threats to terrestrial habitats;
- Gross contamination and general resource degradation concerns.

The ESLs are presented in a series of four lookup tables. Each table reflects a specific combination of soil, groundwater and land-use characteristics that strongly influence the type and magnitude of environmental concerns at a given site. This allows the user to select ESLs that are most applicable to the site being investigated.

The ESL document presents a "tiered" approach to environmental risk assessments. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. In a "Tier 2" assessment, default assumptions used in the Tier 1 screening level model for a specific environmental concern are modified to reflect site-specific conditions. These changes are briefly discussed and justified in the text of the assessment. Examples include the adjustment of direct-exposure screening levels to reflect the actual thickness of contaminated soil at a site or the use of

groundwater monitoring data to evaluate potential leaching concerns, rather than reliance on model-based screening levels. Site data are then compared to the revised screening level(s) for the given environmental concern. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments. Risk assessment models and assumptions that significantly depart from those used to develop the Tier 1 ESLs are described in a more traditional, "Tier 3" risk assessment. The Tier 1 methodology can, however, still provide a common platform to initiate a Tier 3 risk assessment and help ensure that all potentially significant environmental concerns are considered.

**The Tier 1 ESLs presented in the lookup tables are NOT regulatory "cleanup standards".** Use of the ESLs and this document in general is intended to be entirely optional on the part of the regulated facility and subject to the approval of the case manager in the overseeing regulatory agency. The presence of a chemical at concentrations in excess of an ESL does not necessarily indicate that adverse impacts to human health or the environment are occurring; this simply indicates that a potential for adverse risk may exist and that additional evaluation is warranted. ESLs presented for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels (e.g., many petroleum-related compounds). Use of the ESLs as cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more site-specific risk assessment.

Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health, sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. The ESLs do not address potential erosion of contaminated soil and impacts to sediments in nearby aquatic habitats. This is primarily a concern for heavy metals, PCBs and organochlorine pesticides. The need to consider this concern should be evaluated on a site-by-site basis.

**The ESLs should NOT be used to determine when impacts at a site should be reported to the DEQ.** All releases of hazardous substances to the environment should be reported to the appropriate regulatory agency in accordance with governing regulations. The lookup tables will be updated on a regular basis, as needed, in order to reflect changes in the referenced sources as well as lessons gained from site investigations and field observations.

# 1

## Introduction

### 1.1 Purpose

Preparation of detailed, environmental risk assessments for sites impacted by releases of hazardous chemicals can be a time consuming and costly process. Expertise in a multiple of disciplines, including toxicology, geology, ecology, chemistry, physics and engineering, among others, is generally required. For small-business owners and property owners with limited financial resources, the traditional approach is generally not feasible.

As a means to partially address this problem, this document presents a series of comprehensive Environmental Screening Levels (ESLs) that can be directly compared to soil, groundwater and soil gas data collected at a site. Within noted limits, risks to human health and the environment can be considered to be insignificant at sites where concentrations of chemicals of concern do not exceed the respective ESLs. The presence of chemicals at concentrations above the ESLs does not necessarily indicate that a significant risk exists at the site. It does, however, generally indicate that additional investigation and evaluation of potential environmental concerns is warranted.

Screening levels for over 100 commonly detected contaminants are given in a series of "lookup" tables. The tables are arranged in a format that allows the user to take into account site-specific factors that help define environmental concerns at a given property. Correlative screening levels for surface water are also provided.

The introductory text of this document is kept intentionally brief with a focus on the use of the ERLs rather than technical details about their derivation. The latter is provided in the appendices of Volume 2. An electronic version of the lookup tables, the "ESL Surfer", is also available from the CNMI Division of Environmental Quality (DEQ).

### 1.2 Tiered Approach to Environmental Risk Assessments

This document presents a three-tiered approach to environmental risk assessment. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions

are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. A detailed understanding of the derivation of the screening levels is not required for use at this level.

Under "Tier 2", selected components of the models used to develop the Tier 1 ESLs are modified with respect to site-specific data or considerations. Adjustment of Tier 1 screening levels for highly volatile chemicals can be especially useful. Examples include adjustment of the assumed thickness of contaminated soil at a site (soil direct-exposure screening levels), the assumed depth to impacted groundwater (groundwater vapor intrusion screening levels), or use of an agreed upon, alternative target risk level for health risk concerns. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESLs. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments.

Under Tier 3, the person preparing the environmental risk assessment employs alternative models and modeling assumptions to develop site-specific screening or final cleanup levels. In some cases, a "forward mode" human health risk assessment may be desirable to quantify the risk posed to humans and/or ecological receptors at a site prior to remediation ("baseline risk assessment"). The latter is often used by a responsible party to formally document the need to address contamination at a site and attempt to recover costs from other parties in legal actions. Consideration of the methodologies and potential environmental concerns discussed in this document is still encouraged, however. This will help increase the comprehensiveness and consistency of Tier 3 environmental risk assessments as well as expedite their preparation and review.

## **1.3 Comparison To Existing Screening Levels**

1.3.2 This document is modeled after similar approaches to expedited environmental risk assessments developed by the California Environmental Protection Agency (CalEPA 2005), the Hawai'i Department of Health (HDOH 2005) and the United States Environmental Protection Agency (USEPA 2004). The California and Hawai'i documents in essence represent an expansion of the Preliminary Remediation Goals or "PRGs" developed by Region IX of the U.S. Environmental Protection Agency to more comprehensively address potential environmental concerns at contaminated sites. Differences and similarities between the CNMI ESL document and screening levels prepared by the other programs are summarized below.

[Dr. Roger Brewer, the primary author of the CNMI DEQ document, was also responsible for preparation of the California and Hawai'i documents. These documents represent a compilation of approaches developed by various Federal and State environmental agencies in the US, Canada and other countries.]

### 1.3.1 USEPA Region IX PRGs

The U.S. Environmental Protection Agency (USEPA) Region IX "Preliminary Remediation Goals" or "PRGs" are intended to address human health concerns regarding direct exposure to contaminated soils (USEPA 2004). As discussed in that document, the PRGs and "...do not consider impact to groundwater or address ecological concerns." The USEPA PRGs also do not address the potential intrusion of subsurface vapors into buildings, which has gained heightened scrutiny in the US and elsewhere since the mid-1990s. Although guidance to do so is included in the document, the PRGs likewise do not directly address potential cumulative health risks posed by the presence of multiple contaminants at a site.

The CNMI Environmental Screening Levels document can be thought of as an expansion of the USEPA PRGs to address these additional environmental concerns. Specific differences include:

- Adjustment of PRGs for noncarcinogens to reflect a target hazard quotient of 0.2 to address potential cumulative health concerns;
- Addition of direct-exposure screening levels for construction and trench worker exposure to contaminated soils;
- Addition of soil and groundwater screening levels for vapor intrusion (indoor-air impact) concerns;
- Addition of groundwater screening levels for the protection of aquatic habitats/surface water quality;
- Use of a more rigorous leaching model to develop soil screening levels for protection of groundwater quality;
- Addition of soil screening levels for urban area, ecological concerns;
- Addition of soil and groundwater "ceiling levels" to address gross contamination and general nuisance and resource degradation concerns; and
- Addition of soil and groundwater screening levels for Total Petroleum Hydrocarbons (TPH).

1.3.3 Use of the USEPA Region IX PRG models in the RWQCB lookup tables is discussed further in Section 3.2 of Appendix 1. A summary of the direct-exposure models is provided in Appendix 2.

### 1.3.2 Hawai'i DOH EALs

The Hawai'i Department of Health worked in co-ordination with the USEPA in the early 1990s to publish one of the first guidance documents for the preparation of expedited environmental risk assessments (HDOH 1995). Lookup tables of soil and groundwater "environmental action levels" (EALs) included in the document addressed soil direct-exposure concerns (similar to the USEPA Region IX "PRGs") as well as soil leaching and groundwater protection concerns.

The Hawai'i document was updated in 2005 to include a more comprehensive set of environmental concerns very similar to those presented in the CNMI ESL document (HDOH 2005). The updated document is modeled largely after the California EPA document discussed in the following section. Like the CNMI screening levels, the Hawai'i action levels incorporate local drinking water and surface water standards when available. Risk-based action levels presented in the Hawai'i document also reflect USEPA toxicity factors for human health concerns, as do the CNMI ESLs.

Unlike the CNMI ESL document, the Hawai'i EAL document does not present a separate set of action levels for commercial or industrial properties in their summary, Tier 1 lookup tables. Instead, only action levels for residential use of a property are presented. Separate, Tier 1 action levels are also not presented for "deep", isolated soils versus "shallow" soils as included in both the CNMI and California EPA document (see below). Action levels that can be applied to both nonresidential land use and deep soils are, however, included in the appendices of the Hawai'i EAL document. Use of these action levels is permitted in more site-specific, Tier 2 and Tier 3 risk assessments. Hawai'i chose not to include action levels for these site scenarios in their Tier 1 lookup tables in part because in-house risk assessment support was adequate to address these issues on a site-by-site basis as needed.

### 1.3.3 California EPA ESLs

The CNMI ESL document is modeled largely after a similar document prepared by the San Francisco Regional Water Quality Control Board office of the California Environmental Protection Agency (CalEPA 2005). An identical set of potential environmental concerns is presented in the California document. Primary differences in the CNMI ESLs and the California ESLs include:

- Use of CNMI drinking water standards and surface water standards when available;
- Use of USEPA human health toxicity factors;
- Enhancement of the ESL Surfer (electronic lookup tables);
- Inclusion of a document supplement to assist regulators in the review of expedited environmental risk assessments.

The California ESL document was prepared after a careful review of environmental risk assessment guidance documents prepared by other states in the US, including Hawai'i, Massachusetts, Michigan, New York, Oregon, Washington, etc. Guidance prepared by the USEPA, the Ontario Ministry of Environment (Canada) and the Netherlands was also closely referred to. The California document, and in turn the CNMI document, essentially represents a compilation of the most useful and applicable approaches developed by these agencies to expedite the preparation of environmental risk assessments at sites with contaminated soil and groundwater.

### 1.3.4 Hazardous Waste Regulations

Waste is classified as either “hazardous” or “nonhazardous” in part based on Total Threshold Limit Concentrations (TTLC) criteria for solids and Soluble Threshold Limit Concentration (STLC) criteria for liquids. The TTLC and STLC criteria are intended to determine the type of landfill a waste material must be sent to (USEPA Title 22, Section 66699 - Persistent and Bioaccumulative Toxic Waste). Where TTLC or STLC criteria are exceeded, the waste must in general be sent to a Class I, hazardous waste landfill.

In most cases, hazardous waste TTLC and STLC criteria should not be used as soil and groundwater screening or cleanup levels. The criteria, developed in the 1980s, are only loosely based on human health and environmental considerations. STLC values in general reflect drinking water or surface water goals of the time, although some are clearly out-of-date (e.g. trichloroethylene STLC value of 204 mg/L). TTLC values were derived by simply multiplying the STLC value by ten (organic substances) or one hundred (metals).

For most chemicals, TTLC values exceed the most conservative environmental screening levels presented in this document. In the case of Endrin and DDT/DDE/DDD, however, the TTLC is somewhat lower than the screening levels for human health concerns. For example, the TTLC for combined DDT/DDE/DDD is 1.0 mg/kg while the residential, direct-exposure soil screening is 1.7 mg/kg. This presents the enigma that while soil impacted below 1.7 mg/kg is not considered to pose a significant risk to human health, it could be classified as a “hazardous waste” if it were excavated and transported offsite for disposal. Again, this is not a difference of opinion about the potential toxic effects of these chemicals, it is merely a reflection of the less rigorous development of the TTLC values.

Unfortunately, it is not anticipated that the TTLC and STLC values will be revised in the near future. To avoid potential future problems with soil disposal and even public perception, it may be prudent to use TTLCs as final cleanup values for sites where the TTLC is less than cleanup values based on actual risk to human health and the environment.

### 1.3.5 OSHA Standards Permissible Exposure Levels

The National Institute for Occupational Safety and Health (NIOSH) is the US Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury, including exposure to hazardous chemicals in air (NIOSH 2003). NIOSH develops and periodically revises Recommended Exposure Limits (RELs) for hazardous substances in the workplace. The RELs are used to promulgate Permissible Exposure Levels (PELs) under the Occupational Safety and Health Act (OSHA).

In most cases, OSHA exposure limits are not appropriate for health risk evaluations for commercial settings where the chemical is not currently being used as part of a regulated, industrial process. This includes sites affected by the migration of offsite releases (e.g., via emissions from a moving plume of contaminated groundwater). OSHA limits are derived for an occupational setting, where the chemical in question is used in the industrial process, i.e., workers and others who might be exposed to the chemical have knowledge of the chemical's presence, receive appropriate health and safety training, and may be provided with protective gear to minimize exposures. OSHA limits are derived for adult, healthy workers and are not intended to protect children, pregnant women, the elderly, or people with compromised immune systems.

As one example, the current OSHA PEL for tetrachloroethylene (PCE) is 678,000 ug/m<sup>3</sup> (100 ppmv, NIOSH 2003). Comparable risk-based screening levels for commercial/industrial exposure settings included in this document fall between 0.68 ug/m<sup>3</sup> and 10 ug/m<sup>3</sup> (carcinogenic effects vs noncarcinogenic effects, respectively; refer to Table E-3 in Appendix 1). The PEL is applicable to regulated work areas where PCE is being used and the employees have been properly trained to minimize exposure. The risk-based goals are applicable to all other areas.

## 1.4 Chemicals Not Listed In Lookup Tables

The CNMI ELS lookup tables list 100-plus chemicals most commonly found at sites with impacted soil or groundwater. Inclusion of ESLs for additional chemicals is a relatively straightforward process, provided that adequate supporting data are available. To obtain ESLs for chemicals not listed in the lookup tables, the interested party should contact the DEQ. Development of ESLs will be carried out in the same manner as done for the listed chemicals. As an alternative, qualified persons can use the approaches discussed in Appendix 1 of this document to develop ESLs for additional chemicals. The ESLs should be submitted to the DEQ for review and approval (refer also to Section 3.0).

## 1.5 Limitations

**The Tier 1 ESLs presented in the lookup tables are NOT required, regulatory "cleanup standards".** Use of the ESLs as actual cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more detailed environmental risk assessment. The ESLs are intended to be conservative for use at the vast majority of impacted sites in developed areas. As discussed in Chapter 3, however, use of the Environmental Screening Levels may not be appropriate for final assessment of all sites. Examples include:

- Sites that have a high public profile and warrant a detailed, fully documented environmental risk assessment;

- Sites with high rainfall and subsequent high surface water infiltration rates (i.e., infiltration >720mm (28 inches) per year),
- Sites where inorganic chemicals (e.g., metals) are potentially mobile in leachate due to soil or groundwater conditions different than those assumed in development of the lookup tables (e.g., low pH at mine or landfill sites);
- Conservation areas where impacts pose heightened threats to ecological habitats (e.g., presence of endangered or protected species);
- Sites where more than three known or suspected carcinogens or more than five chemicals with similar noncarcinogenic health effects have been identified; and
- Sites affected by tides, rivers, streams, heavy rainfall, etc. where there is a potential for erosion and concentration of contaminants in aquatic habitats.

Examples of other site characteristics that may warrant a more detailed environmental risk assessment are discussed in Chapter 3 (refer also to discussion of screening levels in Appendix 1). In such cases, the information provided in this document may still be useful for identification of potential environmental concerns and development of strategies for preparation of a more site-specific risk assessment.

ESLs for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels. For example, final soil ESLs for Total Petroleum Hydrocarbon (TPH) and many noncarcinogenic, petroleum-related compounds (e.g., xylenes) are driven by the protection of groundwater quality. If long-term monitoring demonstrates that actual impacts to groundwater are insignificant then less stringent soil (and groundwater) screening levels may be warranted. Among other sources, additional guidance regarding the management of impacted soil and groundwater at petroleum-release sites is provided in the following documents (refer also to overseeing regulatory agency):

- *Interim Guidance on Required Cleanup at Low-Risk Fuel Sites* (RWQCBSF 1996);
- *Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates* (SWRCB 2000).

Copies of these documents are provided in the appendices.

Soil ESLs do not consider potential water- or wind-related erosion and deposition of contaminants in a sensitive ecological habitat. This may especially be of concern for contaminants that are known to be bioaccumulative in aquatic organisms (e.g., mercury, PCBs and organochlorine pesticides) or heavy metals that are only moderately toxic to humans but highly toxic to aquatic and terrestrial biota (e.g., copper). Measures should

be taken to mitigate potential erosion and runoff concerns at sites that pose an elevated threat to sensitive aquatic habitats.

It is conceivable that soil, groundwater and soil gas screening levels for the emission of chlorinated, volatile organic compounds to indoor air concerns may not be adequately conservative in some cases. This is most likely to occur in enclosed buildings sites with poor ventilation designs or buildings with flooded basements.

# 2

## Tier 1 Lookup Tables

### 2.1 Organization of Lookup Tables

Environmental risk assessments may be carried out in either a “forward” mode, where actual risks are quantified based on concentrations of a chemical in an impacted media, or “backward” mode, where acceptable concentrations of a chemical in a given media are developed based on specified, target goals. The Environmental Screening Levels (ESLs) presented in this document represents an example of the latter. Tier 1 ESLs for soil and groundwater are summarized in Tables A through E. Individual screening levels were compiled to address the following environmental concerns for each of the chemicals listed in the lookup tables, where applicable and available:

#### Groundwater Quality:

- Protection of human health
  - Current or potential drinking water resource;
  - Emission of subsurface vapors to building interiors;
- Protection of aquatic habitats (discharges to surface water);
- Protection against gross contamination concerns (nuisance, odors, etc.) and general resource degradation.

#### Soil Quality:

- Protection of human health
  - Direct exposure to contaminated soil (ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);
  - Emission of subsurface vapors to building interiors;
- Protection of groundwater quality (leaching of chemicals from soil);
- Protection of terrestrial (nonhuman) habitats;
- Protection against gross contamination concerns (nuisance, odors, etc.) and general resource degradation.

#### Shallow Soil Gas:

- Protection of human health
  - Emission of subsurface vapors to building interiors.

For the purpose of this document, "soil" refers to any unlithified material in the unsaturated zone that is situated above the capillary fringe of the shallowest saturated

unit. A summary of environmental concerns considered in the ESLs is depicted schematically in Figure 1. This is correlative to a “conceptual site model” prepared for a detailed environmental risk assessment. The degree to which any given concern will “drive” environmental risk at a site depends on the actual potential for exposure and the toxicity and mobility of the chemical.

Site characteristics that play an important role in evaluating potential environmental concerns or developing site-specific cleanup levels include:

- Physical location of the impacted soil (e.g., currently or potentially exposed at the ground surface versus isolated in the subsurface);
- Beneficial use of the groundwater immediately underlying the site or otherwise potentially threatened by the release (e.g., drinking water resource threatened versus no drinking water resource threatened);
- Current and anticipated future use of the site (e.g., residential land use permitted or commercial/industrial land use only).

In order to include consideration of these site characteristics in the ESLs, four different tables were prepared (Tables A through D). Each table reflects varying combinations of site characteristics:

- Table A – Shallow soils, potential drinking water resource threatened;
- Table B – Shallow soils, potential drinking water resource not threatened;
- Table C – Deep soils, potential drinking water resource threatened;
- Table D – Deep soils, potential drinking water resource not threatened;

Each of the tables provides separate soil screening levels for residential (i.e., unrestricted) and commercial/industrial land-use scenarios.

For each chemical listed in the lookup tables, screening levels were selected to address each applicable environmental concern under the specified combination of site characteristics. The lowest of the individual screening levels for each concern was selected for inclusion in the summary Tier ESL tables presented in Volume 1 of this document. This ensures that the ESLs presented in these tables are protective of all potential environmental concerns and provides a tool for rapid screening of site data. Where ESLs are exceeded, the detailed tables provided in Appendix 1 can be used to identify the specific environmental concerns that may be present at the site.

An example of the selection of summary, Tier 1 ESLs for tetrachloroethylene (PCE) is presented in Figure 2 (surface soils, drinking water resource threatened, unrestricted land use desired). A more detailed discussion of this example is provided in Appendix 1.

## 2.2 Use of Lookup Tables

The step-by-step use of the lookup tables is summarized below and discussed in more detail in the following sections. A summary of the process is also provided in Figure 3. An outline and discussion of information that should be included in a Tier 1 environmental risk assessment is provided in Section 2.11.

### **Step 1 - ESL Updates and Applicability**

Check with the CNMI DEQ to determine if the ESLs can be applied to the subject site. Ensure that the most up-to-date version of this document is being used (updated every 1-2 years in general).

### **Step 2: Identify All Chemicals of Potential Concern**

An environmental risk assessment must be based on the results of a thorough site investigation, where all chemicals of potential concern have been identified. A summary of the site investigation results should be included in the risk assessment in order for it to be reviewed as a "stand alone" document. A general outline of site investigation information that should be included in a Tier 1 risk assessment is provided in Section 2.11.

### **Step 3: Select Lookup Table(s)**

Determine the designated beneficial use of impacted or threatened groundwater beneath the site. In general, groundwater with a concentration of Total Dissolved Substances (TDS) that is less than 500 mg/L (ppm) and present in a potentially productive aquifer must be initially treated as a current or potential source of drinking water (e.g., Class I or II groundwater recharge zones, see Section 2.4). Next, determine the depth below the ground surface to the top and, where feasible, bottom of contaminated soil (see Section 2.5). This site information is then used to select the most appropriate lookup table (see Figure 3).

### **Steps 4: Determine Desired Land Use (soil ESLs only)**

ESLs for soil are selected based on the present and desired future use of the site. Two options are provided in the lookup tables, "Residential Land Use " or "Commercial/Industrial Land Use Only". Screening levels for residential land used are considered to be adequate for unrestricted use of a property. **For evaluation of commercial/industrial properties, it is highly recommended that site data be compared to ESLs for both unrestricted/residential and commercial/industrial land use.** Reference only to ESLs for commercial/industrial land use may in some cases require that a formal covenant to the deed be prepared that restricts use of the property to

these purposes only. This is primarily a concern for nonpetroleum-related releases (see Section 2.10).

#### **Steps 5 and 6: Select Soil and/or Groundwater ESLs**

Based on the desired land use(s), select appropriate soil ESLs. ESLs for groundwater are provided in the adjacent column of each table and are not dependent on land use or depth to impacted soil. Use of the electronic version of the lookup tables, the “ESL Surfer”, can greatly assist in this task. The Surfer automatically generates one-page summary reports for selected chemicals and site scenarios. These pages can be printed and included in the appendices of the Environmental Risk Assessment report for reference. Correlative screening levels for surface water are also provided. Replace ESLs with naturally occurring, background concentrations of chemicals of concern (e.g., arsenic) or laboratory method reporting levels if higher (see Section 2.9).

#### **Step 7: Determine Extent of Impacted Soil and/or Groundwater**

Using the selected ESLs, determine the extent of impacted soil or groundwater and areas of potential environmental concern at the site and offsite, as required. Soil data should be reported on a dry-weight basis, although adjustment of existing, wet-weight data is generally not necessary (see Appendix 1, Section 6.2). The use of data from filtered groundwater samples is generally acceptable and desirable, although this should be confirmed with the overseeing regulatory agency. For sites where sample data are limited, it will be most appropriate to compare the maximum-detected concentrations of chemicals of concern to the ESLs. For sites where an adequate number of data points are available, the use of statistical methods to estimate more site-specific exposure point concentrations and evaluate environmental risks may be appropriate. The exposure point concentration is generally selected as the lesser of the maximum-detected concentration and the 95% upper confidence interval of the arithmetic mean of sample data. **For residential land use scenarios, soil sample data should be averaged over no more than a 100m<sup>2</sup> (1,000 ft<sup>2</sup>) area. For commercial/industrial areas, soil data may be averaged within known or anticipated outdoor work areas, if needed. For vapor intrusion concerns, groundwater, soil and/or soil gas data should not be averaged over an area larger than the floor space of existing or anticipated buildings.**

Guidance for the estimation of exposure point concentrations, use of “non-detect” data, and other issues is provided in the USEPA document *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002), as well as the California EPA documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a), among other sources. As discussed in these documents, sample data collected outside of impacted areas should generally not be included in estimation of exposure point concentrations.

### **Steps 8 and 9: Evaluate The Need For Additional Investigation or Corrective Actions; Submit Appropriate Reports**

Based on a comparison of available site data to the ESLs, evaluate the need for additional action at the site (e.g. additional site investigation, remedial action, preparation of a more site-specific risk assessment, etc.). This is then summarized in the Tier 1 Environmental Risk Assessment report and workplans for additional corrective actions as needed (see Section 2.11). Decisions for or against additional actions should always be made in conjunction with guidance from the overseeing regulatory agency.

## **2.3 Evaluation of Petroleum Contamination**

Contamination of soil, water and air with petroleum mixtures is evaluated in terms of both Total Petroleum Hydrocarbon (TPH) and target "indicator chemicals" for the given petroleum mixture. A more detailed discussion is provided in Appendix 1. Indicator chemicals typically recommended for petroleum mixtures include (after CalEPA 1996a):

#### **Monocyclic Aromatic Compounds (primarily gasolines and middle distillates)**

- benzene
- ethylbenzene
- toluene
- xylene

#### **Fuel additives (primarily gasolines)**

- methyl tert-butyl ethylene (MTBE)
- tert-butyl alcohol (TBA)
- other oxygenates as necessary

#### **Polycyclic Aromatic Compounds (primarily middle distillates and residual fuels)**

- methylnaphthalene (1- and 2-)
- acenaphthene
- acenaphthylene
- anthracene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- chrysene
- dibenzo(a,h)anthracene
- fluoranthene
- fluorene
- indeno(1,2,3)pyrene
- naphthalene
- phenanthrene
- pyrene

The TPH ESLs should be used in conjunction with ESLs for these chemicals. As discussed in Appendix 1, the "middle distillates" category of TPH includes diesel fuel kerosene, stoddard solvent, home heating fuel, jet fuel and similar petroleum mixtures. "Residual fuels" includes heavy petroleum products such as No. 6 fuel oil ("Bunker C"), lubricating oils, "oil and grease," "waste oils" and asphalts. Soil and groundwater impacted by releases of waste oil may also require testing for heavy metals and chemicals such as chlorinated solvents and PCBs. Screening levels for these chemicals are included in the lookup tables.

Trimethylbenzenes, butylbenzenes, methylnaphthalenes and a number of other common constituents of petroleum products (especially gasolines) are sometimes reported separately in analyses of contaminated soil and groundwater. In general, these constituents should be collectively evaluated under "TPH" and do not need to be evaluated separately. A brief summary of common constituents of gasoline is provided in the New England Interstate Water Pollution Control Commission Leaking Underground Storage Tank bulletin No. 44 (NEIWPC 2003).

## **2.4 Groundwater Beneficial Use**

□ Groundwater designated for use as a source of public water supply should be treated as a potential source of drinking water unless otherwise approved by the DEQ. This includes Class I and II groundwater management zones as described in CNMI water quality regulations (CNMI 2002). In some areas of the islands, Class III (brackish) groundwater is also used as a water supply source for commercial businesses. For the purposes of this document, it is also assumed that all shallow groundwater will ultimately discharge to a body of surface water and potentially impact aquatic organisms (see Section 2.7). Soil and groundwater ESLs were therefore developed to be protective of both drinking water resources and aquatic habitats. This is discussed in greater detail in Chapters 2 and 3 of Appendix 1.

CNMI water quality regulations recognize that site-specific factors may render some groundwater unsuitable for potential drinking water purposes (e.g., elevated TDS in Class III groundwater management zones). Environmental Screening Levels presented in Tables B (shallow soils) and D (deep soils) of this document are intended for use at such sites. The ESLs presented in these tables consider the potential discharge of groundwater to surface water but do not consider potential impacts to sources of drinking water. The ESLs also consider vapor intrusion and "gross contamination" concerns such as the presence of free product or odor concerns if the groundwater were discharged into surface water bodies.

Use of ESLs for nondrinking water areas to screen marginal, Class I or Class II groundwater management zones must be approved by the DEQ but may not necessarily require regulatory "de-designation" of these areas. Site-specific review of some Class I

or Class II areas could indicate unexpectedly high TDS levels in groundwater. Shallow groundwater in near coastal areas could also be trapped in fine-grained soils and sediments that do not have sufficient hydraulic conductivities to permit the installation and use of water supply wells. Unconsolidated geologic units that are comprised of less than 20% sand-size (or larger) material or more than 30% clay-size material are typically not considered to be viable "aquifers" or potential sources of useable groundwater (inferred from Fetter 1994). The potential for a given unit of bedrock to serve as a viable source of groundwater similarly depends on the primary and secondary porosity in the rock and the quality of the groundwater. Consideration must be made, however, for the potential migration of groundwater out of a geologic unit that in itself is insufficiently permeable to be considered to be an aquifer and into a more permeable unit that could serve as a viable source of drinking water.

In general, soil and groundwater screening levels are more stringent for sites that threaten a potential source of drinking water (e.g., compare Tables A and B). This is particularly true for chemicals that are highly mobile in the subsurface and easily leached from impacted soil. For chemicals that are especially toxic to aquatic life, however, screening levels for sites that threaten drinking water resources may be driven by surface water/aquatic habitat protection concerns (e.g., several long-chain hydrocarbons, pesticides and heavy metals). This is discussed in more detail in Appendix 1.

## **2.5 "Shallow" Versus "Deep" Soils**

For the purposes of this document, a depth of three meters (approximately 10 feet) was used to delineate between "shallow" soils, where a potential exists for regular direct exposure of residents and/or office workers, and "deep" soils where only periodic exposure during construction and utility maintenance work is considered likely. This is regarded as the maximum, likely depth that impacted soil could at some point in the future be excavated and left exposed at the surface during typical redevelopment activities (CalEPA 1996). The potential for deeper soils to be brought to the surface in the future should be evaluated on a site-by-site basis based on planned redevelopment or utility maintenance activities.

The full suite of environmental concerns noted in Figure 1 was considered in development of ESLs for shallow soils. For deep soils, regular exposure of residents or commercial/industrial workers and impacts to terrestrial flora and fauna was not considered. As a result, ESLs for relatively non-mobile chemicals are generally less stringent for deep soils than correlative ESLs for shallow soils (e.g., compare PCB ESLs in Tables A and C). For chemicals that are easily leached from soil or potentially emitted to the air as a volatile gas, however, groundwater and indoor-air protection concerns usually drive selection of the final ESL regardless of the depth of the impacted soil. This is the case for several of the highly volatile, chlorinated organic compounds. As a result, correlative shallow and deep soil ESLs are identical (e.g., compare benzene ESLs in Tables A and C).

If impacted soil extends across the three-meter dividing line between shallow soil and deep soil, it may be appropriate to use a separate set of screening levels for each zone (e.g., Table A for the shallow soils and Table C for the deep soils). As discussed in Section 2.10, however, the pros and cons of remediating deep soils to shallow soil criteria should be evaluated on a site-by-site basis. This may help avoid concerns regarding future disturbance and reuse of deeper soils.

As another alternative, the less stringent ESLs for deep soils could be applied to shallower soils under a Tier 2 or Tier 3 risk assessment (refer to Chapter 3), provided that appropriate actions to prevent future exposure and unmanaged reuse are taken. Such controls may include (but not necessarily be limited to):

- Placement and maintenance of adequate cap or other risk-management measures to eliminate potential direct exposure;
- Modeling and/or direct field measurement to evaluate potential impacts to indoor air due to vapor emissions; and
- Preparation of a risk management plan and other appropriate institutional controls (e.g., deed restrictions) in order to prevent unauthorized disturbance of the soil in the future and allow for appropriate management of the soil if it is exposed.

Capping of shallow, contaminated soil and other engineered controls used in place of full cleanup are generally not allowed for properties that are to be used for single-family homes. For more controlled commercial/industrial sites or high-density residential sites, soil with concentrations of contaminants above screening levels for direct-exposure concerns should in general be capped with at least three feet of clean material. If offsite disposal alternatives do not exist, contaminated soil could also be placed under building pads or other paved areas. Preparation of a site-specific Risk Management Plan that clearly identifies the location of the soil and describes future management of these areas may be necessary in some cases, especially if the contaminated soil is not easily recognizable in the field (see Section 2.10). Utility trenches should also be backfilled with clean soil in order to reduce exposure of future workers and avoid accidental reuse of excavated soil in areas where workers and residents may be exposed to residual contaminants.

## **2.6 Land Use**

Land uses are categorized based on the assumed length, duration and magnitude of potential human exposure. The category "Residential Land Use" is intended for use at sites where future land-use restrictions are not desirable or allowed. This includes sites to be used for residences, hospitals, day-care centers and other sensitive purposes (e.g., refer to CalEPA 2002). ESLs listed under this category incorporate conservative assumptions regarding long-term, frequent exposure of children and adults to impacted soils in a residential setting (see Appendices 1, Section 3.2 and Appendix 2). In contrast, the land-use category "Commercial/Industrial Use Only" assumes that only working age adults

will be present at the site on a regular basis. Direct-exposure assumptions incorporated into soil ESLs are less conservative than assumptions used in the residential land-use scenario.

Land use should be selected with respect to the current and foreseeable future use of the site in question. Reference to zoning maps and local redevelopment plans is an integral part of this process. Use of the lookup tables for sites with other land uses (e.g., agriculture, parkland, etc.) should be discussed with and approved by the DEQ. As the category heading implies, use of the soil ESLs listed under "Commercial/Industrial Use Only" places implicit land-use restrictions on the affected property. While this may be considered acceptable for properties currently zoned for such purposes, the need for such restrictions in the future should be seriously weighed against the cost-benefit of remediating the property to meet the sometimes more conservative but less restrictive ESLs for unrestricted land use. Implications for land-use restriction are discussed in more detail in Section 2.10.

## **2.7 Threat To Surface Water Habitats**

Screening levels for freshwater, marine and estuarine water bodies are presented in Table F. These screening levels consider a similar set of environmental concerns as noted for groundwater in Section 2.1. Screening levels for vapor intrusion concerns are excluded, however, while CNMI surface water standards for bioaccumulation concerns have been added. Tidally influenced portions of creeks, streams and rivers and bays they flow into are generally considered to be "estuarine" in screening level assessments. Screening levels for estuarine environments are based on the more stringent of screening levels for marine versus freshwater environments but do not consider drinking water goals.

For the purpose of the Tier 1 lookup tables, it is assumed that impacted or potentially impacted groundwater at all sites could at some time migrate offsite and discharge into a body of surface water. This could occur due to the natural, downgradient migration of groundwater or to human activities such as dewatering of construction sites. Chronic surface water standards (or equivalent) are incorporated into the groundwater screening levels to address potential aquatic habitat protection concerns. In freshwater environments, screening levels (or promulgated standards) for drinking water concerns are generally much lower than correlative standards for toxicity to aquatic organisms. For some pesticides and heavy metals, however, aquatic habitat goals are more stringent than drinking water toxicity goals and therefore take precedence in compilation of Tier 1 ESLs (e.g., dieldrin, endrin and endosulfan). This is reflected in the final groundwater screening levels for these contaminants (refer also to Appendix 1 and the ESL Surfer).

The groundwater screening levels for potential impacts to aquatic habitats do not consider dilution of groundwater upon discharge to a body of surface water. Benthic flora and fauna communities situated below or at the groundwater/surface water interface are

assumed to be exposed to the full concentration of chemicals in impacted groundwater. Use of a generic "dilution factor" to adjust the surface water protection screening levels with respect to dilution of groundwater upon discharge to surface water was therefore not considered. Consideration of dilution/attenuation factor and alternative groundwater screening levels for the protection of surface water quality may, however, be appropriate on a site-specific basis. This may especially be the case in highly developed, waterfront areas with only marginal aquatic habitats remaining (e.g., harbors areas).

Consideration of surface water standards for bioaccumulation concerns in groundwater investigations and cleanup actions may be warranted at sites where large plumes of impacted groundwater threaten to cause long-term impacts to important aquatic habitats. The bioaccumulation standards will generally not need to be considered at sites with small, isolated plumes of impacted groundwater located some distance from a body of surface water. Although these plumes could conceivably migrate offsite and discharge into a body of surface water in the distant future, impacts are likely to be short-lived and the plumes are likely to become significantly diluted as they mix with surface water. The need for a more detailed study of potential groundwater impacts on surface water with respect to bioaccumulation of chemicals in aquatic organisms should be evaluated on a site-by-site basis. This may include the need for more stringent soil cleanup levels (to prevent additional leaching) and development of a more comprehensive, ecological risk assessment.

The soil and groundwater screening levels presented in the lookup tables do not directly address the protection of sediment quality. Site-specific concerns could include the accumulation and magnification of concentrations of highly sorptive chemicals in sediment over time due to long-term discharges of impacted groundwater. This may be especially true for groundwater impacted with highly sorptive (lipophilic) chemicals, including heavy petroleum products.

Potential erosion and runoff of surface soils from impacted sites may also need to be considered, particularly at sites impacted with metals and pesticides that are situated near a sensitive body of surface water. The need for a more detailed, ecological risk assessment of impacts to sediment should be evaluated on a site-by-site basis and discussed with the overseeing regulatory agency.

## **2.8 Screening For Vapor Intrusion Concerns**

### **2.8.1 General Nature of Vapor Intrusion**

Detailed discussions of subsurface vapor intrusion into buildings is provided in the USEPA document *User's Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA 2003) and the California EPA document *Guidance For The Evaluation Of The Vapor Intrusion To Indoor Air Pathway* (CalEPA 2004).

Volatile organic chemicals (VOCs) can be emitted from contaminated soil or groundwater and intrude overlying buildings, impacting the quality of indoor air. While actual impacts to indoor air can vary widely from building to building, and even within buildings, it is generally possible to estimate “worst case” scenarios for use in screening level risk assessments. The development of soil, soil gas and groundwater screening levels were developed for this purpose and incorporated into the ESLs. A summary of approaches used to develop the screening levels is included in Appendix 1.

Heating, ventilation and air conditioning systems (“HVAC” systems), basements, strong winds and other factors can exacerbate vapor intrusion problems by reducing internal air pressure and creating a “vacuum effect” that enhances the advective flow of vapors through building floors (e.g., USEPA 2003, CalEPA 2004b). For buildings with a slab-on-grade design, this can result in the direct flow of subsurface vapors into a building with little or no dilution beforehand. The vapors become diluted as they mix with fresh air being drawn in through the buildings HVAC system or through open doors and windows (generally by a factor of 500 to 1,000 for residential buildings and higher for commercial/industrial buildings, see Appendix 1).

For buildings with a crawl space design, subsurface vapors are diluted as they diffuse into and mix air in the crawl space below the building floor. Additional mixing may or may not occur as the air from the crawl space is pulled into the building. “Vapor flux” through the building floor could be significantly elevated in comparison to slab-on-grade design buildings due to the operation of an HVAC systems in poorly ventilated rooms (e.g., an unvented closet). This issue is still being evaluated. An initial review of published literature and site data, however, suggests that ultimate soil gas-to-indoor air attenuation factors can be very similar to slab-on-grade design buildings.

The field of vapor intrusion investigations is still evolving. Approaches to site investigations and evaluation of vapor intrusion concerns presented in guidance documents noted above and discussed below should not be taken as stringent requirements that must be applied at all sites. Appropriate investigation and risk assessment needs should be determined on a site-by-site basis. Ultimate requirements could be less or more stringent than that presented.

## 2.8.2 Screening For Vapor Intrusion Concerns In The Field

### 2.8.2.1 Stepwise Approach To Vapor Intrusion Evaluation

The direct collection and analysis of indoor air samples may seem to be an easy way to evaluate vapor intrusion concerns. Identification of the source of any VOCs identified is complicated by the presence of the same chemicals in auto emissions and many household goods (aerosol sprays, dry-cleaned clothing, cleaners, etc.), however. For example, ambient levels of benzene in outdoor air in urban areas (related to auto exhaust) typically exceed the indoor air screening level presented in Table E ( $0.085 \text{ ug/m}^3$ ) by an

order of magnitude or more. Ambient levels of dry cleaning solvent (tetrachloroethylene) and other chlorinated solvents in indoor air may also exceed the screening levels presented in Table E.

As an alternative, the sequential collection and evaluation of groundwater data or soil data (see below), soil gas data and, if needed, indoor air data is recommended. These data can then be compared to screening levels for vapor intrusion concerns presented in this document and areas of elevated concern quickly identified. The following approach is recommended (refer also to CalEPA 2004b):

- 1) Compare soil and/or groundwater data to appropriate screening levels for vapor intrusion concerns (see Tables E-1a and E-1b of Appendix 1 or the ESL Surfer, use screening levels for groundwater overlain by high-permeability soils); for sites with significant impacts to vadose-zone soils, proceed directly to Step 2;
- 2) For areas where screening levels for vapor intrusion concerns are approached or exceeded or sites where significant releases to vadose-zone soils have occurred, collect shallow soil gas samples immediately beneath (preferred) or adjacent to buildings and compare results to soil-gas screening levels (refer to Table E in this volume or Table E-2 in Appendix 1).
- 3) At buildings where soil-gas screening levels for vapor intrusion concerns are approached or exceeded, further evaluate the need to carry out an indoor air study (Section 2.8.3).

A more detailed discussion is provided below and in the recent California EPA vapor intrusion guidance document. **Note that site data should in general not be averaged over an area greater than the existing or anticipated floor space area of buildings for initial evaluation of vapor intrusion concerns.**

The screening levels are based on scientific models for vapor intrusion into buildings as well as a growing body of data from actual field investigations. A detailed discussion of the screening levels is presented in Appendix 1.

#### 2.8.2.2 Collection and Evaluation of Groundwater Data

Groundwater data should be collected at all sites where significant releases of VOCs may have occurred and compared to screening levels presented in Appendix 1 of this document (Table E-1a, see also Tables F-1a and F-1b). Vapor emission rates are controlled by the concentration of VOCs in the uppermost part of the water table. Grab sample data from this zone are preferable over data from monitoring wells when

available. This is due to potential mixing effects of groundwater in wells with long screens or with screens that do not span the top of the water table.

Screening levels for groundwater overlain by highly permeable vadose-zone soils are incorporated into the F-series tables in Appendix 1 and the summary tables presented at the end of this volume as well as the ESL Surfer (electronic version of the ESL lookup tables). Alternative screening levels for groundwater overlain by less permeable soils are also presented (Table E-1a). Experience has shown the former are more appropriate for use in screening level assessments. Imported fill material or disturbed native soils should be considered to be highly permeable in site-specific assessments unless vapor flow data into existing buildings indicate otherwise. This is incorporated into the updated USEPA spreadsheets by use of a default vapor flow rate into buildings of approximately five liters per minute per 100m<sup>2</sup> of floor space (“Qsoil”).

**The groundwater screening levels for vapor intrusion concerns are based on an assumed three-meter depth to groundwater (see Appendix 1).** These screening levels may not be adequately conservative for use at sites characterized by a shallower water table. This is offset, however, by the use of conservative target risk levels for potential indoor air impacts. The need to develop more site-specific screening levels or proceed directly to soil gas sampling should be reviewed with the overseeing regulatory agency.

#### 2.8.2.3 Collection and Evaluation of Soil Gas Data

Soil gas samples should be collected at sites where groundwater data suggest potentially significant vapor intrusion concerns. The collection of soil gas data is discussed in the document *Soil Gas Advisory* prepared by the California EPA (CalEPA 2003). Approaches to soil gas studies are also presented in the above-noted vapor intrusion guidance document prepared by the California EPA (CalEPA 2004).

Soil gas samples should be collected over the core of the groundwater plume and in nearby areas of concern (e.g., near residential homes, commercial buildings, utility corridors, etc.). Ideally, samples should be collected immediately beneath the floors of existing buildings (“subslab”). Samples should be collected from paved areas immediately adjacent to buildings if it is impractical to collect subslab samples. In unpaved areas, soil gas samples should be collected from a depth of 1.5m (five feet) below ground surface. Samples collected from depths less than 1.5m are considered unreliable due to the increased potential to draw in ambient, surface air (CalEPA 2004b).

If site-specific modeling of vapor flow rates or indoor-air impacts is to be carried out, the collection of additional soil geotechnical data should be considered (soil grain-size analysis, moisture content and fraction organic carbon). Data collected from soils within 1.5m of the ground surface and well above the water table are especially pertinent in the models. The collection of deeper soil gas samples and soil-type data may also be useful in evaluating the lateral and vertical extent of VOCs in the subsurface. The use of lab-

based, soil vapor permeability data to override the default vapor flux rate ( $Q_{\text{soil}}$ ) of 5 liters/minute (per 100m<sup>2</sup> of ground floor area) used in the USEPA models is, however, discouraged. These tests often do not adequately take into account enhanced permeability due to soil heterogeneities, soil fractures, relict root structures, shallow fill material, disturbance during redevelopment, and other types of secondary permeability.

Both subslab sample data and shallow soil gas data (i.e.,  $\leq 1.5\text{m}$  bgs) should be compared to the soil gas screening levels presented in Table E. Where screening levels are approached or exceeded, the need to carry out an indoor air study should be more closely evaluated. Approaches for determining when an indoor air study should be carried out are still being developed. The California EPA vapor intrusion guidance recommends that an indoor air study be carried out if site-specific, soil-gas-to-indoor vapor intrusion models suggest that impacts to indoor air may exceed a cumulative excess cancer risk of  $10^{-6}$  or a noncancer hazard index  $>1.0$  (CalEPA 2004).

While this approach is generally appropriate for sensitive land use scenarios (e.g., residential, day care, etc.), it may be impractical in areas of high ambient outdoor air pollution or for commercial/industrial buildings where similar chemicals are being used or stored inside of the building. For example, the concentration of benzene and other auto exhaust-related contaminants in outdoor air can exceed risk-based screening levels by up to two orders of magnitude. In such cases, impacts to indoor air related to vapor intrusion from subsurface contamination can easily be masked by existing outdoor pollution. Sampling of indoor air would not be useful. Decisions for cleanup of contaminated soil and groundwater for vapor intrusion concerns should instead be based on an evaluation of soil gas data in conjunction with ideal, target indoor air goals (even if these goals cannot be currently met due to other sources of contamination, including vehicle exhaust in ambient air). If soil gas screening levels are exceeded, then cleanup of the source areas to reduce vapor intrusion concerns should be considered.

An alternative approach for determining when indoor air studies are needed at commercial/industrial (C/I) settings if soil gas screening levels for commercial/industrial sites are exceeded is described below:

#### Step 1. Confirm and Evaluate Soil Gas Data.

- Confirm soil gas data with a second round of sampling in targeted areas of potential concern (e.g., co-located with hot spots identified in first round of soil gas data collection and previously identified hot spots in soil and/or groundwater). If significant differences in reported concentrations of VOCs are reported at individual sample points and ESLs were exceeded in one or both sampling events, consider the installation of permanent vapor monitoring wells in a denser grid (e.g., 15m to 20m grid) and additional sampling until the range of potential site conditions is adequately defined. Statistical approaches may be required at sites where wide temporal variations in concentrations of VOCs in soil gas are identified.

- If soil gas ESLs for noncarcinogens are not exceeded and ESLs for carcinogens are not exceeded by more than one order of magnitude (equivalent to a target risk of  $10^{-5}$ ), then no further action is warranted (refer to Table E-2 in Appendix 1).
- If soil gas ESLs are exceeded by more than amounts noted above, use the USEPA soil gas spreadsheet to calculate a site-specific, cumulative excess cancer risk and noncancer hazard index (USEPA 2003, see web address in references). For example, input site-specific building and soil type data into USEPA spreadsheet for each chemical of concern and add up the calculate risks and hazard indices. Input a default vapor flux rate of 5 L/min per 100m<sup>2</sup> of floor space. Print out spreadsheet results for each chemical of concern; calculate cumulative risks and include in letter report with recommendations for additional actions (see Step 2). [The USEPA spreadsheet protection password is “ABC.”]

Step 2. Evaluate site-specific vapor intrusion risks.

- **Site-specific, cumulative excess cancer risk  $<10^{-5}$  and/or cumulative noncancer hazard index  $<1.0$  (and potential impacts to indoor air less than existing pollution in ambient, outdoor air).** Testing of indoor air not required. Install permanent vapor monitoring probes in areas of primary concern and test quarterly for a period of one year to confirm soil gas data. If concentrations of VOCs do not increase significantly (i.e., to exceed cumulative  $10^{-5}$  excess cancer risk or  $HI > 1.0$ ), no further action is warranted under current site conditions. Additional evaluation may be warranted if building conditions change or if new buildings are constructed over impacted areas.
- **Site-specific, cumulative excess cancer risk  $>10^{-5}$  and/or cumulative noncancer hazard index  $>1.0$ .** Install permanent vapor monitoring probes and resample soil gas. If resampling of soil gas indicates a potential indoor air risk  $<10^{-5}$  and/or cumulative noncancer hazard index  $<1.0$ , carry out quarterly monitoring for one year to confirm (see above). Carry out indoor air testing if soil gas data suggest a potential excess cancer risk of  $>10^{-5}$  and/or a cumulative noncancer hazard index  $>1.0$  is confirmed (refer to Section 2.8.3).

The above approach for commercial/industrial settings is intended to be general guidance only and should not be used as a strict requirement. The appropriateness of the approach should be evaluated on a case-by-case basis.

#### 2.8.2.4 Soil Gas and Tight Soils

At sites where soil gas samples cannot be collected using traditional methods due to tight soil conditions (e.g., wet, clayey soils), other approaches should be attempted. In many cases, simply moving the collection probe over a few feet from the initial location will address the problem. If problems still persist, the installation of temporary soil vapor

probes encased in permeable sand packs and capped with a bentonite clay mixture can be considered (refer to CalEPA 2002). The diameter and depth of the vapor probe borehole should be adjusted to allow sufficient pore space for the collection of soil gas samples. Adequate time (generally several weeks) should be allowed for VOCs in the surrounding clays to equilibrate with soil gas in the vapor probe sand pack.

Passive soil gas sampling techniques may also prove useful in tight soils, provided that the actual concentrations of VOCs present can be quantified (e.g., recent advances in “Gore<sup>TM</sup> Sorbers”). This approach has not been widely used at this time and is still being evaluated. Where possible, both “active” and passive soil gas data should be collected in amenable areas of a site and used to verify the interpretation of passive soil gas data from areas where active data could not be collected.

At sites where groundwater is impacted with VOCs and the collection of soil gas data is simply not possible, groundwater data should be compared to conservative screening levels and the need to go directly to crawl space and/or indoor air sampling evaluated. At “soil only” sites, soil data should be similarly collected and compared to conservative screening levels (see below).

#### 2.8.2.5 Use of Soil Data

Soil screening levels for potential vapor intrusion concerns are incorporated in the ESL lookup tables (see Appendix 1, Table A-D series and Table E-1b). At sites where minor releases of volatile chemicals have occurred (e.g., restricted spills around underground tank fill ports), direct comparison of soil screening levels to site data is generally acceptable. If soil screening levels are exceeded, the need to collect soil gas samples and further evaluate vapor intrusion concerns should be evaluated. **At sites where significant releases of volatile chemicals have occurred, the direct use of soil gas data in conjunction with soil data is strongly recommended.**

An advantage of the soil vapor intrusion model is the inclusion of “mass-balanced” considerations in the evaluation of potential long-term impacts to indoor air. As discussed in the following section, this issue is not included in the soil gas vapor intrusion models or corresponding screening levels. (Mass balance issues are also not considered in the groundwater models. The continued migration of contaminated groundwater from upgradient areas is assumed to provide an ongoing source of VOCs to areas of concern, however, and mass-balance issues are less relevant.)

#### 2.8.2.6 Soil Gas and Mass-Balance Issues

At sites with high levels of VOCs in soil gas but a limited total mass of VOCs in soil, a mass balanced approach to the evaluation of vapor intrusion concerns may be appropriate. For example, it is not uncommon to find relatively high levels of PCE in soil gas immediately beneath the floors of dry cleaners but relatively little PCE in soil

samples collected in the same area. Most of the PCE is in vapor phase, with very little total mass present. This is most likely related to the presence of dry soil with very little organic carbon directly under the floor of the building.

Based on soil gas data alone, the vapor intrusion models may predict unacceptable, long-term impacts to indoor air. The actual mass of VOCs present may be insufficient to maintain initial impacts over the full span of the exposure duration assumed in development of the screening levels, however. In such cases, the screening levels presented in could be overly conservative for evaluation of long-term, chronic health risk concerns and a more site-specific evaluation of vapor intrusion concerns may be warranted. Additional information on this subject is provided in Section 3.3.2 under Tier 2 assessments.

### 2.8.3 Collection and Evaluation of Indoor Air Data

The collection of indoor data will be necessary to further evaluate vapor intrusion concerns in some cases. The collection of indoor air data in absence of soil gas and, if applicable, crawl space is not recommended. Such data are critical in determining the source of any VOCs identified in indoor air. Guidance on the collection and evaluation of indoor air data is provided in the above-noted California EPA document (CalEPA 2004) and will not be repeated in detail here. Additional information is available in the Massachusetts Department of Environmental Protection document *Indoor Air Sampling And Evaluation Guide* (MADEP 2002).

The California EPA guidance document provides a table of recommend actions at sites where impacts to indoor air are identified (CalEPA 2004). A slightly modified version of that table is provided below:

<b>*Indoor Air Sampling Results</b>	<b>Response</b>	<b>Activities</b>
Risk: $<10^{-6}$ HI: $<1.0$	Minimal	Confirm that vapor intrusion impacts are not likely to increase in the future.
Risk: $10^{-4}$ to $10^{-6}$ HI: 1.0 to 3.0	Monitoring +/- Mitigation	Collect soil gas, indoor air and/or crawl space samples semi-annually as appropriate. Mitigation may be recommended in some cases to reduce exposure even though health risk goals may not be exceeded.
Risk: $>10^{-4}$ HI: $>3.0$	Mitigation Required	Institute engineering controls to mitigate exposure and collect soil gas samples and indoor air samples semiannually to verify mitigation of exposure.

\*Contaminants identified in indoor air that are directly linked to the intrusion of subsurface vapors.  
 Risk = Cumulative excess cancer risk  
 HI = Hazard Index – Cumulative risk posed by sum of noncancer hazard quotients of specific chemicals of concern.

If buildings or homes in the subject area are underlain by crawl spaces then the concurrent collection air samples from these areas should also be considered. Crawl space data should be compared directly to indoor air data. As discussed above, the dilution of VOCs in crawl spaces as the air is pulled into a building is difficult to predict.

The above are initial recommendations only. Ultimate actions required at a given site should be determined on a case-by-case basis in coordination with the overseeing regulatory agency. As noted in the California EPA guidance document, indoor air data should be used to better ascertain human health concerns when potentially significant impacts are implied by soil gas and other subsurface data. The California EPA document recommends that at least two rounds of indoor data be collected prior to determining appropriate response activities. The scope of specific responses should be determined on a case-by-case basis in coordination with the overseeing regulatory agency. Active mitigation of indoor air impacts may be recommended (or even required) at sites where a need to reduce exposure of individuals is desired even though health risk objectives noted

above are not exceeded. A contingency plan based on the data to be collected should be included as part of the indoor air sampling plan.

If vapor intrusion concerns are primarily for future buildings, then remediation of VOC impacts prior to construction should be considered. If this is not feasible (e.g., impacts due to continuing offsite source) then engineered controls to mitigate vapor intrusion concerns should be incorporated into future building designs. The scope and oversight of these controls should be determined on a site-specific basis in coordination with the overseeing regulatory agency. Long-term oversight requirements are typically much more stringent for residential properties. In some cases, formal incorporation of engineered controls in building permits may be warranted with long-term oversight of the controls being undertaken by the local municipal agency.

## **2.9 Substitution of Laboratory Reporting Limits and Ambient Background Concentrations for ESLs**

In cases where an ESL for a specific chemical is less than the laboratory method reporting limit for that chemical (as agreed upon by the overseeing regulatory agency), it is generally acceptable to consider the method reporting limit in place of the screening level. Potential examples include the soil health-based ESLs for dioxin (e.g., 0.0000046 mg/kg for residential exposure).

Background concentrations of metals in soils are presented in the summary lookup tables in cases where they exceed screening levels for human health and environmental concerns. This is particularly an issue for naturally occurring arsenic in soils. Background concentrations of arsenic in soils typically ranges from approximately 5 mg/kg to 20 mg/kg, with some soils containing in excess of 40+ mg/kg arsenic (refer to Appendix 1). This is well above the health-based, direct-exposure goals for arsenic in soil of 0.39 mg/kg (residential exposure) and 1.9 mg/kg (commercial/industrial exposure) presented in the appendices.

For use in this document, an assumed background level of 20 mg/kg arsenic is referenced (HIDOH 2005). If background levels of total arsenic are clearly exceeded at a site then a laboratory-based assessment of arsenic bioaccessibility (fraction that could be released in the stomach from ingested soil) should be carried out and used to determine the need to remove or isolate the soil. A similar approach should be taken for total chromium and other naturally occurring metals as needed on a site-by-site basis.

## **2.10 Implied Land-Use Restrictions Under Tier 1**

Allowing the option to tie screening levels or cleanup levels to site-specific land use and exposure conditions can save considerably in investigation and remediation costs. For

example, the screening level for polychlorinated biphenyls (PCBs) in surface soils is 0.22 mg/kg in residential areas but up to 7.4 mg/kg for commercial/industrial areas (adjusted to a target risk of  $10^{-5}$ ). Even higher levels of PCBs could potentially be allowed to remain in place onsite provided that adequate controls to mitigate potential exposure are put into effect (e.g., permanent cap, protection of groundwater, etc.).

The use of final cleanup levels less stringent than those appropriate for unrestricted land use will, however, place restrictions on future use of the property. For example, if a site is remediated using ESLs (or alternative criteria) intended for commercial/industrial land use then the site should not be used for residential purposes in the future without additional evaluation. In some cases, this may require that a formal covenant to the deed be recorded to restrict future use of the property. Deed covenants are generally not recommended for petroleum-release sites. This is due in part to the large number of sites potentially involved but also to the anticipated natural degradation of the contaminants over time as well as the relative ease that petroleum-contaminated soil or groundwater can be recognized in the field.

The use of ESLs for deep soils at a site similarly assumes that the impacted soil will remain isolated below the ground surface "for eternity". For single-family, residential areas, future disturbance of soil situated greater than three meters is generally considered to be unlikely (CalEPA 1996a) and use of the ESLs for deep soil below this depth without restrictions may be reasonable (see Section 2.5). During the redevelopment of properties for commercial/industrial or high-density residential use, however, excavation and removal of soils from depths in excess of five or even ten meters could take place (e.g., for underground parking garages, elevator shafts, utilities, etc.). The need to impose enforceable, institutional controls for proper management of deep, impacted soils at properties where the subsurface ESLs (or alternative cleanup levels) are applied should be discussed with the overseeing regulatory agency on a site-by-site basis.

Land-use restrictions inherent in the selection of ESLs from the Tier 1 lookup tables (or assumptions used in site-specific risk assessments) should be kept as minimal as possible. **Concentrations of chemicals in impacted soils left in place at a commercial/industrial site should always be compared to both commercial/industrial AND residential ESLs (or alternative criteria for unrestricted land use).** If the soils in fact meet ESLs for unrestricted land use after cleanup then this should be clearly stated in the site closure report. Recognizing this point may prove important should the site unexpectedly become desirable for other use in the future (e.g., residential, school day care, health care, etc.). **Assumptions that impacted soil at a property will remain isolated at shallow depths under pavement, buildings or some other type of "cap" should likewise be avoided if at all possible.** Such assumptions place significant and oftentimes unnecessary restrictions on the future use and redevelopment of a site. If done, appropriate covenants to the property deed should be prepared and methods to prevent or manage future disturbance of the soil should be clearly described and ensured. A foresighted approach in the use of Tier 1 ESLs or

alternative, site-specific cleanup levels will allow more flexibility in future use of a site, help avoid unexpected complications during site redevelopment and minimize the liability of future land owners.

## **2.11 Cumulative Risks at Sites With Multiple Chemicals of Concern**

Risks posed by direct exposure to multiple chemicals with similar health effects are considered to be additive or "cumulative." For example, the total risk of cancer posed by the presence of two carcinogenic chemicals in soil is the sum of the risk posed by each individual chemical. The same is true for chemicals that cause noncarcinogenic health effects. A summary of example target health effects for the chemicals listed in the lookup tables is provided in Appendix 1 (Table L).

Use of ESLs for single chemicals is limited to the extent that the screening levels remain protective of human health should other chemicals with similar health effects also be present. Soil ESLs are considered to be adequate for use at sites where no more three carcinogenic chemicals or five chemicals with similar noncarcinogenic ("systemic") health effects are present. This is based on a combination of conservative exposure assumptions and target risk factors in direct-exposure models. Refer to Appendix 1, Section 1.3, for additional discussion of this subject.

## **2.12 Framework For a Tier 1 Environmental Risk Assessment**

Tier 1 environmental risk assessments should serve as "stand alone" documents that provide a good summary of environment impacts at a site and assess the threats posed to human health and the environment by these impacts. The risk assessment can be prepared as a component of a site investigation or remedial action report or as a separate document. Information on each of the topics listed below should be addressed in report that presents the risk assessment, however (after MADEP 1995). Together, this information is intended to provide a basic "conceptual model" of site conditions. The level of detailed required for each topic will vary depending on site-specific considerations.

### **1. Summarize Past, Current and Anticipated Future Site Activities and Uses:**

- Describe past and current site uses and activities;
- Describe foreseeable future site uses and activities. **(Always include a comparison of site data to ESLs for residential/unrestricted land use to evaluate need for formal covenants to the deed; see Section 2.10).**

### **2. Summary of Site Investigation:**

- Identify all types of impacted media;

- Identify all sources of chemical releases;
  - Identify all chemicals of concern;
  - Identify magnitude and extent of impacts that exceed ESLs to extent feasible and applicable (include maps of site with isoconcentration contours for soil and groundwater);
  - Identify nearby groundwater extraction wells, bodies of surface water and other potentially sensitive ecological habitats;
  - Ensure data are representative of site conditions.
3. Summarize Appropriateness of Use of Tier 1 Lookup Tables and ESLs (see Section 1.5):
- Do Tier 1 ESLs exist for all chemicals of concern?
  - Does the site have a high public profile and warrant a fully documented, detailed environmental risk assessment?
  - Do soil and groundwater conditions at the site differ significantly from those assumed in development of the lookup tables (e.g., low pH at mine sites)?
  - Do impacts pose a heightened threat to sensitive ecological habitats (e.g., presence of endangered or protected species)?
  - Have more than three carcinogens or five chemicals with similar noncarcinogenic health effects been identified (see Section 2.11)?
  - Other issues as applicable to the site.
4. Soil and Groundwater Categorization (see Sections 2.4 and 2.5):
- State the regulatory beneficial use of impacted or potentially impacted groundwater beneath the site; discuss the actual, likely beneficial use of groundwater based on measured or assumed quality of the groundwater and the hydrogeologic nature of the soil or bedrock containing the groundwater.
  - Characterize the soil type(s) and location of impacted soil as applicable to the lookup tables (e.g., soil stratigraphy, soil texture and permeability, depth to and thickness of impacted soil, etc.).
5. Exposure Point Concentrations (see Section 2.2, Step 7):
- Identify maximum concentrations of chemicals present in impacted media.
  - Describe how alternative exposure point concentrations were determined (e.g., 95% UCLs), if proposed, and provide supporting data. **For residential land use scenarios, sample data should be averaged over no more than a 100m<sup>2</sup> (1,000 ft<sup>2</sup>) area. For vapor intrusion concerns, groundwater, soil and/or soil gas data should not be averaged over the floor space area of existing or anticipated buildings.**
  - Discuss the need to evaluate groundwater data with respect to surface water standards for potential bioaccumulation of chemicals in aquatic organisms due to the size of the plume, the proximity of the plume to a body of surface water and the potential for minimal dilution of groundwater upon discharge to surface water (see Section 2.7).

- Discuss how background concentrations of chemicals were determined, if considered for use in the risk assessment (see Section 2.9).
6. Selection of Tier 1 ESLs and Comparison to Site Data (see Section 2.2)
- Summarize how Tier 1 ESLs were selected with respect to the information provided above and additional assumptions as applicable.
  - Compare site data to the selected summary Tier 1 ESLs (presented in Volume 1) and discuss general results.
  - If desired or recommended, compare site data to detailed ESLs for individual environmental concerns (presented in Volume 2, Appendix 1) and discuss specific, potential environmental concerns present at site.
7. Conclusions (see Section 2.10):
- Describe the extent of soil and groundwater impacts above Tier 1 ESLs, using maps and cross sections as necessary.
  - Discuss if a condition of potential risk to human health and the environment exists at the site.
  - Discuss if a more site-specific risk assessment is warranted at the site.
  - Present a summary of recommended future actions proposed to address environmental concerns at the site.
  - Discuss the need to impose land-use restrictions and institutional controls at the site based on the results of the Tier 1 assessment (e.g., requirements for caps, etc.; need for covenant to deed to restrict land use to commercial/industrial purposes only, etc).

The above list is not intended to be exhaustive or representative of an exact outline required for all Tier 1 risk assessments. Requirements for completion of an adequate site investigation and Tier 1 environmental risk assessment should be discussed with the overseeing regulatory agency.

# 3

## **Tier 2 and 3 Environmental Risk Assessments**

### **3.1 Conditions Warranting More Detailed Risk Assessments**

Use of the Tier 1 Environmental Screening Levels is optional and independent environmental risk assessments may be undertaken for at site. In some cases, site conditions may negate the full use of the Tier 1 ESLs and require preparation of a Tier 2 or Tier 3 risk assessment. Examples of site conditions that may warrant a more site-specific or detailed risk assessment include (see also Section 1.5):

- Sites where alternative target risk levels or chemical-specific toxicity factors may be acceptable to the regulatory agency (see Appendix 1, Sections 1.3 and 3.2);
- Sites where the thickness of vadose-zone soils impacted by volatile organic compounds is greater than three meters (soil screening levels for potential indoor air concerns may not be adequately conservative; see Section 2.8 and Appendix 1, Section 3.3);
- Sites where groundwater monitoring data are adequate to be used in place of model-derived screening levels for leaching of residual contaminants from soil (site unpaved and/or main mass of impacted soil in contact with groundwater; see Appendix 1, Section 3.4);
- Sites where inorganic chemicals (e.g., metals) could be leached out of soil and pose a threat to groundwater (see Appendix 1, Section 3.4);
- Sites with soils impacted by pesticides, where final screening levels are driven by leaching concerns and potential impacts to aquatic habitats but the site is not located near a body of surface water (e.g., dieldrin, endrin, endosulfan, etc.);
- Sites where the depth to groundwater is greater than ten meters below the base of impacted soil (soil screening levels for leaching concerns may be excessively conservative; see Appendix 1, Section 3.4);

- Sites where protected terrestrial habitats or other ecologically sensitive areas are threatened (soil ESLs may not be adequately conservative; see Appendix 1, Section 3.5);
- Sites where engineered controls will be implemented to eliminate or reduce specific exposure pathways (avoid whenever possible; see Section 2.10);
- Sites where the future erosion of shallow soils could lead to significant transport and concentration of contaminants in sensitive ecological habitats; and
- Sites where field observations or site conditions otherwise indicate that the ESLs may not be adequately conservative or may be excessively conservative.

Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health; sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where these concerns may be present (see Section 3.3.5).

Evaluation of landfills and sites impacted by mine wastes may in particular require the preparation of a detailed, site-specific assessment of groundwater and surface water impact concerns due to the possible elevated mobility of metals and other chemicals and potential explosive gases concerns (e.g., methane). Soil leaching models incorporated into the Tier 1 ESLs assume typical, ambient physio-chemical conditions in soil and groundwater (e.g., soil pH 5.0 to 9.0) and the relatively immobility of heavy metals and organic chemicals with very high sorption factors (e.g., PCBs, PAHs, etc.). This assumption may not hold true at many landfill and mine sites, where extreme pH and Eh conditions could lead to substantial mobility of these compounds. In these and other related cases, more rigorous field and laboratory studies may be required to adequately assess risk to human health and the environment.

Final surface water and groundwater screening levels for several pesticides that are highly toxic to aquatic organisms are very stringent (e.g., dieldrin, endrin, endosulfan, etc.; refer to Tables A-D in this volume and Table F series in Appendix 1). Correlative soil screening levels for leaching concerns are likewise very stringent (refer to Table A-D series in Appendix 1). The pesticides in question are only moderately mobile in the environment. The final soil and groundwater screening levels are likely to be excessively conservative for sites not located near a body of surface water. The need to apply the screening levels to soil and groundwater data should be evaluated on a site-by-site basis.

Less conservative screening levels for evaluation of human-toxicity concerns only may be appropriate at many sites.

Site-specific risk assessments are grouped under the loosely defined terms "Tier 2" and "Tier 3". The nature of these risk assessments is briefly discussed below.

## **3.2 Tier 2 Environmental Risk Assessments**

### **3.2.1 Purpose**

Tier 2 environmental risk assessments are intended to be relatively easy and cost-effective to prepare. Preparation of Tier 2 risk assessments will require a thorough understanding of the Tier 1 ESLs being re-evaluated, however. Under Tier 2, specific Tier 1 screening levels are adjusted or deleted to more closely reflect site conditions or alternative risk assumptions. Replacing only targeted components of the Tier 1 ESLs reduces the need to prepare and justify an independent, detailed risk assessment when Tier 1 ESLs cannot or should not be fully applied. This greatly reduces the time and cost incurred by both the regulated business and the overseeing regulatory agency in finalizing the risk assessment.

For example, the Tier 1 screening level for leaching concerns may not need to be considered at sites where groundwater monitoring data indicate that leaching impacts from soil to groundwater are minimal or not posing an adverse risk. A common modification under Tier 2 may also include the adjustment of target risk level for carcinogens in soils at commercial/industrial sites from  $10^{-6}$  to a cumulative risk of  $10^{-5}$  or a cumulative hazard index of 1.0 (and likely preparation of a covenant to the deed that formally restricts land use). This could increase the direct-exposure screening levels for carcinogens by a factor of up to ten. In these examples, all other components of the Tier 1 ESLs are retained for use in the risk assessment. The modifications to Tier 1 assumptions are described and justified in the text of the report and the revised set of screening levels are presented.

The ESL document is accompanied by Tier 2 spreadsheet models for soil direct-exposure concerns and soil leaching concerns. Contact CNMI DEQ for copies of the models.

### **3.2.2 Example Tier 2 Modifications of Tier 1 ESLs**

A more detailed list of potential, site-specific modifications to Tier 1 screening levels is presented below. These examples are not intended to reflect the full range of modifications possible. Where noted, Tier 2 ESL spreadsheets are available from DEQ for calculation of site-specific screening levels. Use of the spreadsheets is discussed in the following sections.

### **Groundwater Screening Levels**

#### Drinking Water:

- Exclusion of drinking water impact concerns based on natural groundwater quality or geologic characteristics of groundwater containing unit (e.g., brackish groundwater in coastal areas);

#### Vapor Intrusion (Tier 2 spreadsheet available):

- Use of site-specific data for model input parameters (depth to groundwater, soil properties, building characteristics, target risk or hazard index, etc.);
- Use of soil gas and/or indoor air data to more directly evaluate potential impacts;
- Use of alternative chemical toxicity factors or target risk levels;

#### Surface Water Impacts:

- Exclusive use of freshwater or saltwater screening levels;
- Consideration of alternative surface water screening levels;
- Consideration of groundwater monitoring data and observed plume migration over time;
- Consideration of site-specific dilution effects during potential discharge of groundwater to surface water (generally not recommended except in highly developed and disturbed water front properties);

#### Gross Contamination:

- Use of alternative ceiling levels and/or site-specific observations and considerations regarding gross contamination concerns;

#### General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the ESL.

### **Soil Screening Levels**

Direct Exposure (Tier 2 spreadsheet available):

- Use of site-specific soil data, including thickness of contaminated soils;
- Use of alternative chemical toxicity factors or target risk levels;
- Use of alternative screening level for lead at sites where backyard gardens or other exposure scenarios considered in ESLs are not anticipated (refer to Appendix 1, Section 3.2.3);
- Elimination of direct-exposure concerns through imposition of institutional controls;
- Exclusion of direct-exposure concerns due to depth of impacted soil below ground surface (e.g., >10 meters bgs).

Vapor Intrusion:

- Use of soil gas and/or indoor air data to more directly evaluate potential impacts (generally recommended);
- Use of alternative chemical toxicity factors or target risk levels.

Groundwater Protection (leaching effects, Tier 2 model available):

- Consideration of alternative, target groundwater levels;
- Use of site-specific soil and groundwater data in leaching models;
- Use of groundwater monitoring data to evaluate leaching impacts and groundwater quality concerns in place of soil screening levels (most appropriate in unpaved areas and/or at sites where the main mass of chemical is in contact with groundwater);
- Use of laboratory leaching test to evaluate potential groundwater impacts (see Section 3.3.3).

Ecological Impact Concerns:

- Use of alternative screening levels based on site studies or published data;
- Reconsideration of need to include eco-based screening levels in highly developed or industrialized areas.

Gross Contamination:

- Use of alternative ceiling levels and/or site-specific observations and considerations for gross contamination concerns.

### **Soil Gas Screening Levels**

- Use of indoor air data to more directly evaluate potential health risk concerns;
- Use of soil gas data to calibrate mass-balanced evaluation of potential vapor intrusion impacts.

#### **General:**

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the ESL.

In each of these examples, an alternative screening level is generated for the specified environmental concern and re-compared to site data. Models and assumptions used to generate each of the Tier 1 screening levels are discussed in detail in Appendix 1. The format of the Tier 2 Environmental Risk Assessment Report should be similar to that outlined for Tier 1 reports. Adjustments to Tier 1 screening levels should be clearly described and justified within the report and additional information included as necessary.

It is beyond the current scope of this document to provide detailed examples of potential Tier 2 assessments. A discussion of mass-balance issues and soil gas data is presented below, however, given the current emphasis on the vapor intrusion exposure pathway.

### **3.2.3 Tier 2 Soil Direct-Exposure Model**

The CNMI ESL document includes an Excel-based spreadsheet model for calculation of site-specific, Tier 2 direct-exposure screening levels for soil. The DEQ should be contacted to obtain a copy of the spreadsheet.

The USEPA model used to generate Tier 1 soil screening levels for direct-exposure concerns assumes that an “infinite source” of contaminant of concern is present in the soil of a given site (refer to Appendix 1). For non-volatile and relatively immobile and persistent contaminants, this assumption is not significant since concentrations of the chemical in soil can be expected to remain relatively constant over time (e.g., PCBs). For volatile chemicals, however, this is a very important and limiting assumption. The USEPA infinite source model assumes the steady emission of a volatile chemical from contaminated soil over time and subsequent long-term impacts to outdoor air (USEPA 1996, 2004). This progressively depletes the mass of the chemical in the soil over time.

For highly volatile chemicals such as vinyl chloride and even benzene, maintaining the theoretical vapor emission rate over an assumed 30-year exposure period would require the area of contaminated soil be tens of meters thick. This is not realistic for most sites.

The Tier 2 direct-exposure model includes an alternative, “mass-balanced” volatilization factor published by USEPA that allows the user to take into account the actual thickness of contaminated soil at a given site (USEPA 1996). In this model, the long-term, average vapor emission rate is limited by the total mass of the contaminant present and the assumed exposure duration (maximum average vapor emission rate = total mass of contaminant present divided by the assumed exposure duration). The spreadsheet is relatively easy to use. The user selects the chemical of concern from a dropdown list and adjusts soil parameter values with respect to site-specific data as available (primarily the thickness of contaminated soil). The spreadsheet then automatically generates Tier 2, direct-exposure screening levels for both residential and commercial/industrial land use. Exposure assumptions can also be adjusted in the spreadsheet (exposure duration, target risk etc.), although most of these assumptions are essentially “fixed” for the noted exposure scenario and will require review by a toxicologist for approval.

Note that Tier 2 screening levels for nonvolatile chemicals are likely to be identical to the Tier 1 screening levels. This is because the thickness of contaminated soil at a site (or more correctly the mass of the contaminant present) does not play a significant role in estimating the risk or calculating soil screening levels for nonvolatile contaminants. It is also important to remember that groundwater protection concerns (i.e., soil leaching) and vapor intrusion concerns may require additional cleanup at sites even though direct-exposure concerns have been adequately addressed.

### 3.2.4 Tier 2 Groundwater Vapor Intrusion Model

In most cases, the collection of shallow soil gas samples is recommended at sites where groundwater screening levels for vapor intrusion concerns are exceeded (refer to Section 2.8). It is feasible, however, that more detailed groundwater models may be desired at some sites. The USEPA model used to generate Tier 1 groundwater screening levels for this concern can be used for this purpose. A copy of the USEPA spreadsheet (initially set to Tier 1 default parameter values) is available from DEQ. A copy of pertinent parts of the USEPA user’s manual that accompanies the spreadsheet is included in the appendices.

As discussed in Appendix 1, the Tier 1 model vapor intrusion model assumes that groundwater is within three meters of the floor of a building and that the vadose-zone soils are relatively permeable to vapors. The building is assumed to be a small, one-story structure with an indoor-air exchange rate of one to two-times per hour (residential vs commercial/industrial site scenario, respectively).

The Tier 2 model allows for the input of site-specific soil parameter values such as moisture content and vapor permeability. It is recommended, however, that only the depth to groundwater and site-specific building parameters be modified in a Tier 2 scenario. The model is very sensitive to changes in soil moisture. Overestimating the moisture content of the soil can cause the model to significantly underestimate potential impacts to indoor air. If site-specific soil parameters are included in the model, a minimum 15cm-thick unit of dry, highly permeable fill material (“sand”) should always be included as the top layer of the model (refer to top soil layer in Tier 1 model). This is necessary to ensure that the model generates a vapor flux rate (volume of subsurface vapors moving into a building per unit time) of approximately four to five liters per minute, per 100m<sup>2</sup> of floor space. Vapor flux rates in this range are well verified by field studies and should be considered a default for Tier 2 models.

### 3.2.5 Tier 2 Soil Leaching Model

The Tier 1 soil screening levels used in the CNMI ESL document were generated using a simplified, SESOIL-based algorithm that incorporates fixed assumptions about site characteristics (refer to Appendix 1). Unfortunately, the algorithm cannot be adjusted to reflect site-specific conditions in a simple, Tier 2 assessment.

It is recommended that the full SESOIL model (or equivalent) be used for more site-specific, Tier 3 evaluations of leaching concerns at sites where concentrations of organic contaminants in soil exceed Tier 1 screening levels for leaching concerns and site-specific groundwater data are not adequate to evaluate this concern. Use of SESOIL in site-specific evaluations is discussed in the 1995 HDOH Risk-Based Corrective Action document (HDOH 1995). A copy of this discussion is provided in Appendix 5 of this document.

As an alternative, the Excel-based Tier 2 soil leaching model included with the CNMI ESL document can be used (Tier 2 Soil Leaching). A copy of the model can be obtained from the DEQ. The model relies on a highly simplistic contaminant partitioning equation presented in the USEPA *Soil Screening Guidance* document (USEPA 1996). This is used in conjunction with a corresponding leachate dilution factor model to back calculate Tier 2 screening levels for soil leaching concerns. Site-specific parameters that can be input into the model include the soil porosity, moisture content and organic carbon content as well as aquifer hydraulic conductivity, groundwater gradient, and surface water infiltration rate. A summary of the model equations is provided in the appendices.

The model is again relatively simple to use. The target contaminant is selected from a dropdown list. Default soil and groundwater parameter values are adjusted to reflect site-specific data as available. A leachate dilution factor is calculated based on the assumed groundwater flow rate and the rate of infiltrating surface water. Based on the calculated dilution factor and the input target groundwater goal, the model back calculates an “acceptable” concentration of the contaminant in the soil leachate. Using a simple

contaminant partitioning equation, the model then calculates a “Tier 2”, total soil concentration that corresponds to the target concentration of the contaminant in the soil leachate.

While very amenable to the input of site-specific soil and groundwater characteristics, the USEPA model does not take into account the actual fate and transport of the leachate through the vadose zone on its journey to groundwater. This is a very significant shortcoming for evaluation of highly volatile, highly sorptive and/or highly biodegradable contaminants in soil. These concerns are partially addressed in the more rigorous (but non-site-specific) SESOIL algorithm used to generate Tier 1 screening levels (refer to Appendix 1). **Because of this, the Tier 1 screening level will in many case be higher than the “Tier 2” screening level.** This is because the simplistic Tier 2 model does not take into account the actual fate and transport of contaminants as the leachate migrates through the vadose zone, as does SESOIL. The USEPA model is in particular excessively conservative for highly volatile, highly biodegradable and/or highly sorptive chemicals and should not be relied upon to evaluate these types of chemicals. If this is the case and additional evaluation of soil leaching is desired, the full SESOIL model (or equivalent) or a laboratory-based evaluation of potential leaching concerns should be carried out (refer to Section 3.3.3).

Alternative soil leaching models for petroleum contaminants are currently under development by USEPA. These models consider specific carbon ranges of petroleum compounds rather than reliance on Total Petroleum Hydrocarbon data. The CMNI DEQ should be contacted for information on the availability of these models.

### **3.3 Tier 3 Environmental Risk Assessments**

#### **3.3.1 Purpose**

Under Tier 3, alternative models and assumptions are used and fully justified to develop a detailed, comprehensive environmental risk assessment. Portions of the Tier 1 models may still be retained for some components of the risk assessment. A detailed review of the preparation of Tier 3 environmental risk assessments is beyond the scope of this document. A few potentially useful methods and some general cautions are highlighted below. Example references for the preparation of Tier 3 risk assessments are provided at the end of this section.

#### **3.3.3.2 Laboratory-Based Soil Leaching Tests**

Laboratory-based soil leaching tests offer an alternative to the use of conservative, model-derived soil screening levels for groundwater protection concerns (refer to Section 3.4 in Appendix 1). These tests may be especially useful for evaluating soils impacted by inorganic chemicals (e.g., metals and salts) and relatively nonsorptive and nonvolatile

organic chemicals. Screening levels for leaching of metals from soil are specifically excluded from this document. Where releases of metal compounds to soil are identified, groundwater monitoring (if appropriate) and/or laboratory-based leaching tests should be carried out to fully evaluate potential leaching impacts (refer to Section 3.4 of Appendix 1).

The USEPA Synthetic Precipitation Leaching Procedure (SPLP) is one example of laboratory-based soil leaching tests (USEPA 1994). The SPLP test differs from the more commonly referenced Toxicity Characteristic Leaching Procedure (TCLP) for hazardous waste in that it is specifically designed to evaluate the mobility of organic and inorganic compounds in soils. The results of an SPLP test are compared to regulatory levels for disposal of materials in landfills and this is then used to determine the type of landfill most appropriate for disposal of the soil (e.g., lining, leachate collection system requirements, etc.).

The SPLP test was **not** specifically developed to evaluate leaching of chemicals from soil outside of a controlled, landfill environment but can be used to do so with some caveats. From a groundwater protection standpoint, one goal is to predict the dissolved-phase concentration of a chemical in the pore space of a saturated soil sample (i.e. the leachate) through either models or laboratory tests. The SPLP test does **not** directly provide this information. Using the SPLP test method, 100 grams of soil are added to two liters of reagent water, the sample is mixed for a specified period of time, and an extract of the reagent water is analyzed for targeted chemicals. The volume of reagent water added to the sample significantly exceeds the volume of the sample pore space. This leads to significant dilution of the potential "leachate" had the volume of added reagent water only been equal to the volume of the sample pore space.

For example, the pore volume of a 100-gram sample of soil with 35% effective porosity is approximately 20 cm<sup>3</sup> (assumes bulk density of 1.8, total volume 57 cm<sup>3</sup>). Adding two liters, or 2,000 cm<sup>3</sup>, of water to the sample therefore introduces a laboratory-based, leachate "dilution factor" of approximately 100 to the SPLP test results (volume reagent divided by volume sample pore space). Concentrations of chemicals reported under the SPLP test could therefore be up to 100 times less than the dissolved-phase concentration of the chemical in a saturated sample.

The inherent dilution effect of the SPLP test method is only significant for chemicals that are highly mobile and not significantly volatile (or biodegradable). From a fate and transport perspective, the dilution factor inherent in the SPLP test could be considered to reflect the decrease in chemical concentrations due to resorption, volatilization and dilution as the leachate migrates downward and mixes with groundwater. Based on comparisons of soil leaching models that take these fate and transport considerations into account (e.g., SESOIL, see Appendix 1) and those that don't (e.g., USEPA 1996), the dilution factor inherent in the SPLP test method appears to be adequately conservative for chemicals that are at least moderately sorptive (i.e., sorption coefficient of at least 100

cm<sup>3</sup>/g) or highly volatile (i.e., Henry's Constant of at least 0.001 atm-m<sup>3</sup>/mole.). **For moderately sorptive and/or volatile chemicals, the results of the SPLP test can be directly compared to target groundwater goals.** This includes most of the organic chemicals listed in the ESL lookup tables (refer to Table J in Appendix 1).

Chemicals listed in the ESL document that are not adequately sorptive or volatile to justify unmodified use of the SPLP test method include all inorganic compounds (e.g., metals and perchlorate) as well as acetone, 2,4 dinitrophenol and methyl ethyl ketone (very low sorption coefficients). Other organic chemicals that fail this test but only moderately include bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, chloraniline, 1,2 dibromoethane, 2,4 dimethylphenol, 2,4 dinitrotoluene, MTBE, phenol, 1,1,1,2-tetrachloroethane and 1,1,2,2-tetrachloroethane. **For these and other relatively nonsorptive and nonvolatile chemicals not listed in the ESL tables, the results of the SPLP test should be multiplied by a factor of 100 (or a sample-specific factor) to negate the method-related dilution effect.** The sample results can then be adjusted with respect to chemical-specific and site-specific Dilution/Attenuation Factors (DAFs) that take into account volatilization, resorption, degradation and other factors anticipated to reduce the concentrations of chemicals in leachate as the leachate migrates downward and ultimately mixes with groundwater.

Relatively simple DAFs that only address mixing of leachate with groundwater can be calculated using equations provided in the USEPA *Soil Screening Guidance* (USEPA 1996), among other sources. A spreadsheet version of the dilution equation is provided in the Tier 2 Soil Leaching model included with the CNMI ESL document (refer to Section 3.2.5).

### 3.3.43.3.3 Tier 3 Environmental Risk Assessments for Parklands

For initial cleanup efforts at sites to be used as parks or wildlife refuges, it is strongly recommended that such areas be remediated to meet unrestricted land use (i.e., assumed residential exposure, target Excess Cancer Risk of one-in-a-million; target Hazard Index of 1.0 and address potential ecological concerns). From a strictly toxicological standpoint, a typical recreational-use exposure scenario may suggest that substantially higher concentrations of contaminants could be left in place at the site and not pose a threat to human health. Public parks are typically frequented by children, young mothers, elderly people and other groups of people with potentially elevated sensitivities to environmental contaminants, however. In addition, cleanup levels based on recreational land-use scenarios are oftentimes higher (less stringent) than levels that would be allowed for commercial/industrial properties. This intuitively goes against the concept of developing a park as "refuge" for humans and wildlife. Assumption of a limited exposure frequency and duration (e.g., 100 days per year for ten years) also puts an inherent restriction on the number of days and years that an individual can visit the park without exceeding potential health hazards. Long-term, future uses of such properties are also difficult to predict.

In some cases, remediation of proposed parklands to unrestricted land-use standards may not technically or economically feasible. This should be evaluated on a site-specific basis and receive approval from the overseeing regulatory agency. In such cases, the appropriateness of allowing unrestricted access to the area should be carefully evaluated. This could include the need to impose access restrictions on the property (i.e., based on the exposure assumptions used in the risk assessment) and/or cap impacted soils with a minimal amount of clean fill. It may also be prudent to post signs at the property entrance that warn of potential health hazards (see Section 2.10).

#### 3.3.53.3.4 Tier 3 Reference Documents

Potentially useful reference documents for preparation of Tier 3 environmental risk assessments include the following:

##### **Human Health Risk Assessment:**

- *Superfund Exposure Assessment Manual* (USEPA 1988)
- *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A)* (USEPA 1989a);
- *Soil Screening Guidance: Technical Background Document* (USEPA 1996);
- *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites* (CalEPA 1994a);
- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b);
- *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a);
- *Exposure Factors Handbook* (USEPA 1997a);
- *Standard Provisional Guide for Risk-Based Corrective Action* (ASTM 1995); and
- *Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces* (Johnson et. al, 1998, Johnson 2002).

##### **Ecological Risk Assessment:**

- *Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual* (USEPA 1989b);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997b), and

- *Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a,b).

The above list of references is not intended to be comprehensive. Additional risk assessment guidance should be referred to as needed.

# 4

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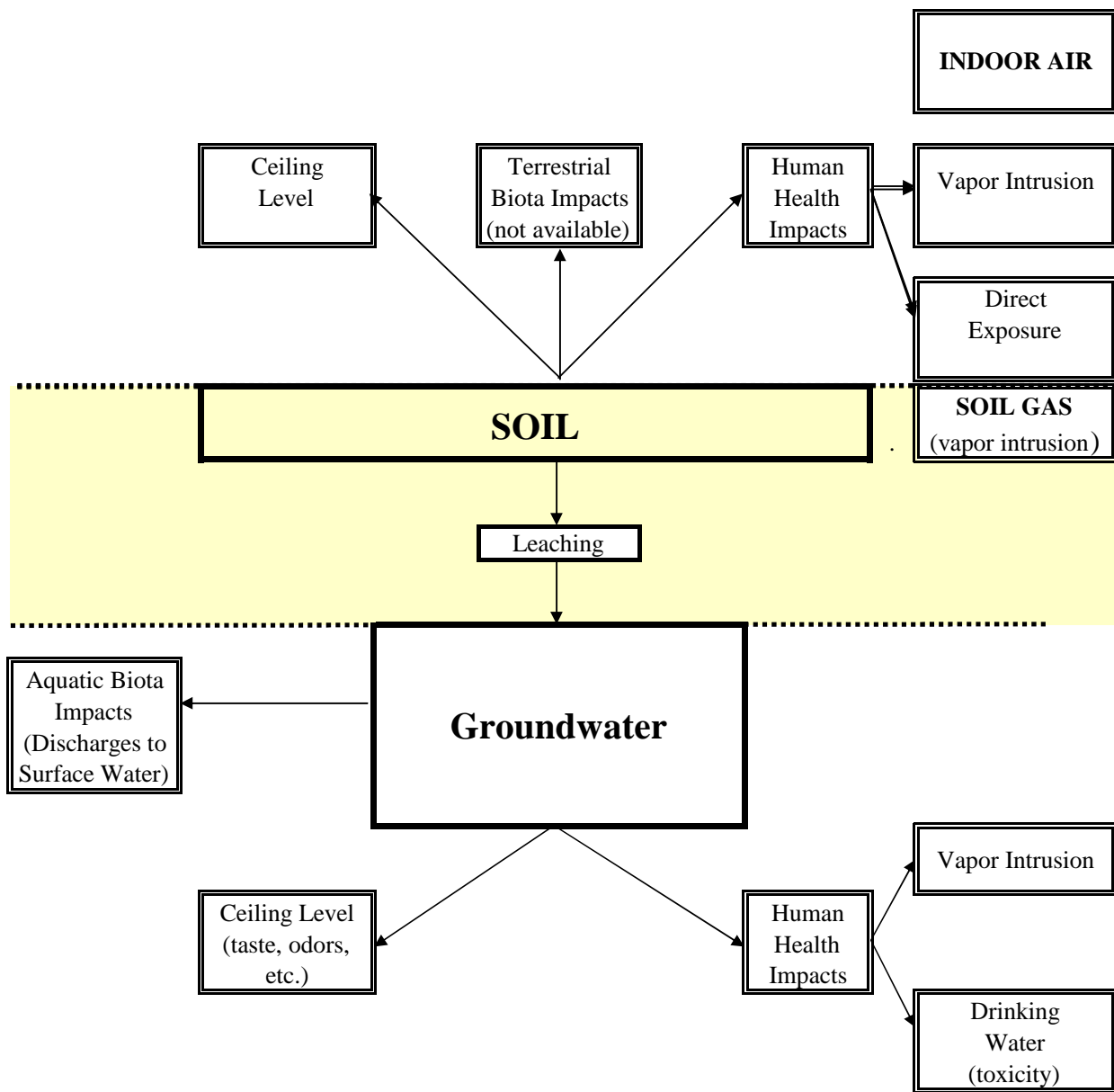
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# FIGURES





**Figure 1. Summary of human health and environmental concerns considered in screening levels. Additional site-specific considerations include groundwater beneficial use, depth to impacted soil, soil type and land use. This figure is intended for Tier 1 and Tier 2 assessments only. Evaluation of environmental concerns not shown requires site-specific assessment.**

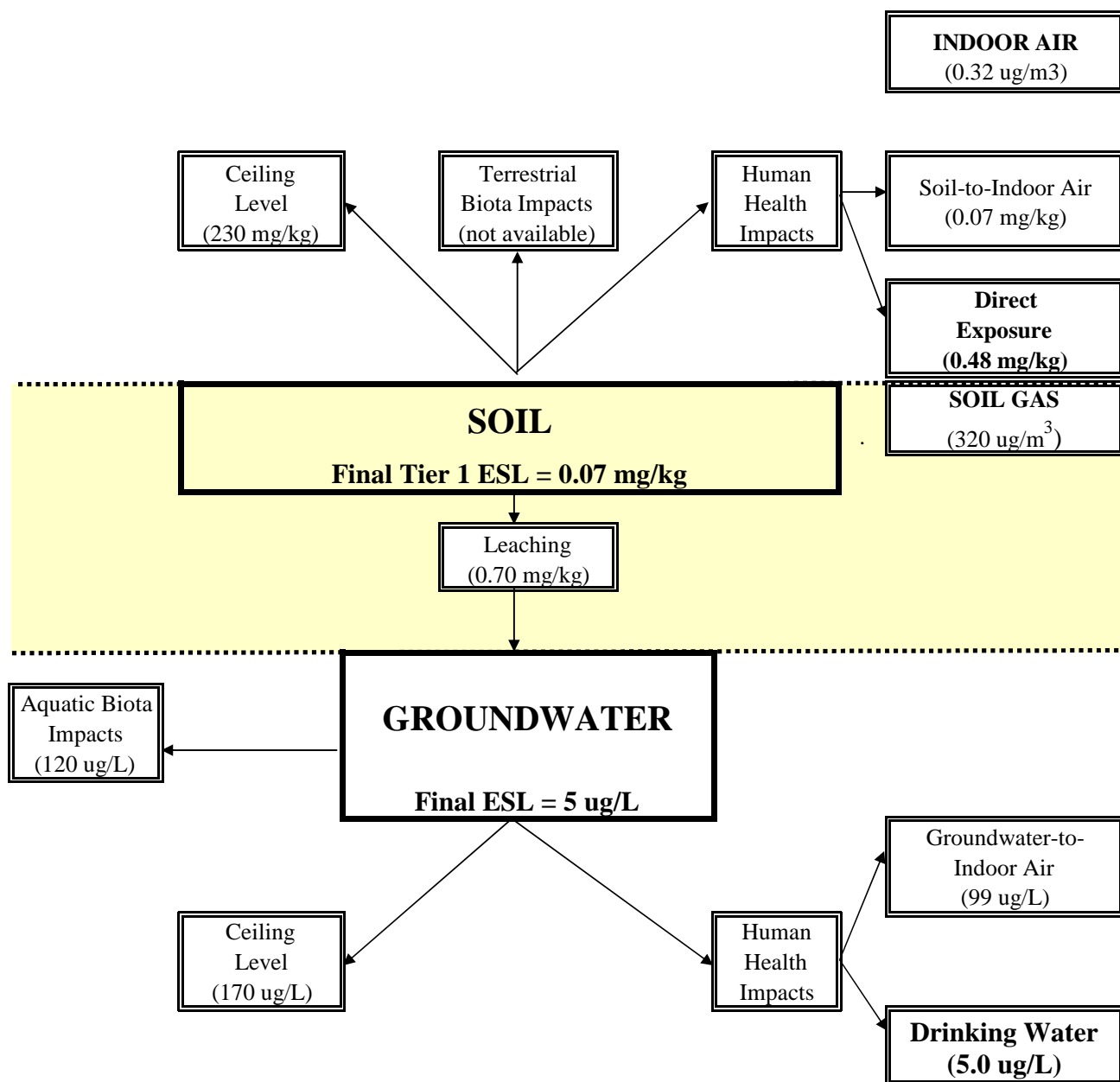


Figure 2. Summary of individual screening levels used to select final, Tier 1 ESLs for tetrachloroethylene in soils situated within ten feet of the ground surface and in groundwater that is a current or potential source of drinking water, based on a residential land-use scenario. Final ESLs presented in Volume 1 summary tables are the lowest of the individual screening levels. Vapor intrusion concerns drive selection of the final soil ESL (0.07 mg/kg). For groundwater, drinking water toxicity concerns drive selection of final ESL (5.0 ug/L).

**STEP 1:** Check with the overseeing regulatory agency to ensure that the version of the lookup tables you have is up-to-date and that the screening levels can be applied to your site (see Section 1.5).

**STEP 2:** Select chemicals of potential concern for site based on knowledge of past site use and/or analytical data for soil or groundwater samples collected at the site.

**STEP 3:** Choose appropriate lookup table based on location of impacted soil and beneficial use of impacted or potentially impacted groundwater at the subject site, as summarized below:

<sup>1</sup> <b>BENEFICIAL USE OF THREATENED GROUNDWATER</b>	<sup>2</sup> <b>LOCATION OF IMPACTED SOIL</b>	
	<b>Shallow Soils (≤ 3m bgs)</b>	<sup>3</sup> <b>Deep Soils (&gt; 3m bgs)</b>
Current or Potential Source of Drinking Water	TABLE A	TABLE C
NOT a Current or Potential Source of Drinking Water	TABLE B	TABLE D

bgs: below ground surface

1. Shallow-most saturated zone beneath the subject site and deeper zones as appropriate.
2. Depth to top of impacted soil from ground surface (3 meters = 10 feet).
3. Application of deep soil ESLs to soils <3m deep may require institutional controls (see text).

**STEP 4:** Go to selected lookup table. Determine desired or anticipated future use of property - "Unrestricted Residential Land Use Permitted" (recommended for initial use at all sites to avoid potential deed restrictions) vs "Commercial/Industrial Land Use Only".

**STEP 5:** Select soil ESLs for chemicals of concern from appropriate land-use column in table and/or select correlative groundwater ESLs.

**STEP 6:** Replace ESLs with approved laboratory method detection limit if detection limit is greater than the ESL. Replace ESLs with natural background concentration of chemical if background is higher (see text and notes at end of tables).

**STEP 7:** Determine vertical and lateral extent of soil and/or groundwater impacted above screening levels to extent required by overseeing agency AND/OR use selected ESLs as guide for re-use of excavated, impacted soil.

**STEP 8:** Evaluate additional corrective actions needed at site based on results of Step 7 (e.g., cleanup to Tier 1 ESLs, track and monitor defined groundwater plume, develop alternative screening levels in a site-specific, Tier 2 or Tier 3 environmental risk assessment, etc.). Determine specific environmental concerns for site as needed using screening levels presented in Appendix 1.

**STEP 9:** Submit Tier 1 Environmental Risk Assessment and work plans for additional corrective actions, as necessary, to overseeing regulatory agency.

**Figure 3. Steps to selection and use of Environmental Screening Levels in Tier 1 Lookup Tables (see Section 2.2).**



# TABLES



**TABLE A: SHALLOW SOIL ( $\leq 3$ M BGS) - WATER IS A  
CURRENT OR POTENTIAL SOURCE OF  
DRINKING WATER**

**Notes:**

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).



**TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3\text{m}$  bgs)**  
**Groundwater IS Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	2.9E-02	1.0E-01	4.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	6.0E+00
ARSENIC	2.0E+01	2.0E+01	1.0E+01
BARIUM	7.5E+02	1.5E+03	2.0E+03
BENZENE	2.2E-01	2.2E-01	5.0E+00
BENZO(a)ANTHRACENE	6.2E+00	1.2E+01	2.7E-02
BENZO(a)PYRENE	6.2E-01	2.1E+00	1.4E-02
BENZO(b)FLUORANTHENE	6.2E+00	2.1E+01	9.2E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(k)FLUORANTHENE	3.7E+01	3.7E+01	4.0E-01
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.2E-04	1.2E-04	9.5E-03
BIS(2-CHLOROISOPROPYL)ETHER	3.0E-03	3.0E-03	2.7E-01
BIS(2-ETHYLHEXYL)PHTHALATE	3.5E+01	1.0E+02	6.0E+00
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	3.4E-03	3.4E-03	1.8E-01
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	1.7E-01	3.4E-01	8.5E+00
CADMIUM	7.8E+00	1.2E+01	2.5E-01
CARBON TETRACHLORIDE	2.7E-02	9.6E-02	5.0E+00
CHLORDANE	1.6E+00	6.5E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	2.7E-01	2.7E-01	3.9E+00
CHLOROFORM	1.8E-02	6.3E-02	6.2E+01
CHLOROMETHANE	3.2E+00	9.5E+00	1.6E+02
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	2.1E+02	2.2E+02	7.4E+01
CHROMIUM III	7.5E+02	7.5E+02	7.4E+01
CHROMIUM VI	8.0E+00	8.0E+00	1.1E+01
CHRYSENE	2.3E+01	2.3E+01	3.5E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHRACENE	6.2E-01	2.1E+00	9.2E-03
DIBROMO,1,2- CHLOROPROPANE,3-	4.5E-03	4.5E-03	2.0E-01
DIBROMOCHLOROMETHANE	1.1E-02	1.1E-02	1.3E-01
DIBROMOETHANE, 1,2-	4.6E-04	4.6E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

**TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3\text{m}$  bgs)**  
**Groundwater IS Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	6.5E-02	2.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	4.0E-02	4.0E-02	1.5E-01
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	2.4E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	1.9E+00	1.9E+00	4.7E+01
DICHLOROETHANE, 1,2-	1.6E-02	4.5E-02	5.0E+00
DICHLOROETHYLENE, 1,1-	1.2E+00	1.2E+00	7.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.2E+00	2.2E+00	7.0E+01
DICHLOROETHYLENE, Trans 1,2-	2.5E+00	6.7E+00	1.0E+02
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	2.1E-02	7.5E-02	5.0E+00
DICHLOROPROPENE, 1,3-	4.6E-02	4.6E-02	4.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.3E-01	7.3E-01	1.1E+02
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.3E+01
DINITROTOLUENE, 2,4-	2.5E-01	2.5E-01	3.4E+01
DIOXANE, 1,4-	3.7E-03	3.7E-03	6.1E+00
DIOXIN (2,3,7,8-TCDD)	3.9E-06	1.6E-05	3.0E-08
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+00	4.5E+00	5.0E+04
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.3E-02	1.3E-02	3.6E-03
HEPTACHLOR EPOXIDE	1.4E-02	1.4E-02	3.6E-03
HEXACHLOROBENZENE	3.0E-01	1.1E+00	1.0E+00
HEXACHLOROBUTADIENE	3.7E+00	4.3E+00	8.6E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	1.2E+01	1.6E+01	4.8E+00
INDENO(1,2,3-cd)PYRENE	6.2E+00	2.1E+01	9.2E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	4.7E+00	1.0E+01	7.7E-01
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYL ETHYL KETONE	6.4E+00	6.4E+00	7.0E+03
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00
METHYLENE CHLORIDE	6.7E-02	6.7E-02	4.3E+00
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00

**TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3$ m bgs)**  
**Groundwater IS Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
MOLYBDENUM	4.0E+01	4.0E+01	1.8E+02
NAPHTHALENE	1.2E+00	1.2E+00	6.2E+00
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	3.0E+00	5.0E+00	1.0E+00
PERCHLORATE	7.0E-03	7.0E-03	3.7E+00
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	2.3E-02	2.3E-02	3.7E+00
TETRACHLOROETHANE, 1,1,1,2-	7.6E-03	7.6E-03	4.3E-01
TETRACHLOROETHANE, 1,1,2,2-	9.9E-04	9.9E-04	5.6E-02
TETRACHLOROETHYLENE	6.9E-02	2.4E-01	5.0E+00
THALLIUM	1.0E+00	1.3E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	5.0E+02	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	3.2E-01	1.1E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	2.6E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	3.6E-02	1.3E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.2E+00	1.2E+00	3.7E+00
VANADIUM	1.6E+01	2.0E+02	1.9E+01
VINYL CHLORIDE	2.0E-02	1.6E-01	2.0E+00
XYLENES	2.3E+00	2.3E+00	2.0E+01
ZINC	6.0E+02	6.0E+02	8.1E+01

**TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3$ m bgs)**  
**Groundwater IS Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ZINC	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable
<b>Notes:</b> 1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface. 2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.) 3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system. Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2. Source of groundwater ESLs: Refer to Appendix 1, Table F-1a. Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2). Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. <b>Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.</b> Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. <b>Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).</b> Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7). Refer to appendices for summary of ESL components. Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables). TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.			

**TABLE B: SHALLOW SOIL ( $\leq 3$ M BGS) - WATER IS NOT  
A CURRENT OR POTENTIAL SOURCE OF  
DRINKING WATER**

**Notes:**

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.4).



**TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3\text{m}$  bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	2.9E-02	1.0E-01	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	3.0E+01
ARSENIC	2.0E+01	2.0E+01	3.6E+01
BARIUM	7.5E+02	1.5E+03	2.0E+03
BENZENE	5.3E-01	1.4E+00	4.6E+01
BENZO(a)ANTHRACENE	6.2E+00	1.2E+01	2.7E-02
BENZO(a)PYRENE	6.2E-01	2.1E+00	1.4E-02
BENZO(b)FLUORANTHENE	6.2E+00	2.1E+01	9.2E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(k)FLUORANTHENE	3.7E+01	3.7E+01	4.0E-01
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	6.7E-03	2.8E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	3.5E+01	1.2E+02	3.2E+01
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	2.3E-02	8.2E-02	2.7E+02
BROMOFORM	6.1E+01	6.9E+01	3.2E+03
BROMOMETHANE	1.7E-01	5.1E-01	1.6E+02
CADMIUM	7.8E+00	1.2E+01	2.5E-01
CARBON TETRACHLORIDE	2.7E-02	9.6E-02	9.8E+00
CHLORDANE	1.6E+00	6.5E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	2.7E-01	2.7E-01	3.9E+00
CHLOROFORM	1.8E-02	6.3E-02	6.2E+01
CHLOROMETHANE	3.2E+00	9.5E+00	1.9E+03
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	2.1E+02	2.2E+02	7.4E+01
CHROMIUM III	7.5E+02	7.5E+02	7.4E+01
CHROMIUM VI	8.0E+00	8.0E+00	1.1E+01
CHRYSENE	2.3E+01	2.3E+01	3.5E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHTRACENE	6.2E-01	2.1E+00	2.5E-01
DIBROMO,1,2- CHLOROPROPANE,3-	4.5E-03	4.5E-03	2.0E-01
DIBROMOCHLOROMETHANE	1.7E-02	2.2E-02	1.6E+02
DIBROMOETHANE, 1,2-	7.2E-04	2.5E-03	1.6E+01
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01

**TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3$ m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	6.5E-02	2.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	1.1E+00	3.8E+00	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	2.4E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	1.9E+00	1.9E+00	4.7E+01
DICHLOROETHANE, 1,2-	1.6E-02	5.6E-02	1.3E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.2E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	2.5E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	2.1E-02	7.5E-02	1.0E+02
DICHLOROPROPENE, 1,3-	1.0E-01	3.6E-01	1.2E+02
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.3E-01	7.3E-01	1.1E+02
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
DIOXANE, 1,4-	3.0E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	3.9E-06	1.6E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+00	4.5E+00	5.0E+04
ETHYLBENZENE	3.2E+01	3.2E+01	2.9E+02
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.3E-02	1.3E-02	3.6E-03
HEPTACHLOR EPOXIDE	1.4E-02	1.4E-02	3.6E-03
HEXACHLOROBENZENE	3.0E-01	1.1E+00	3.7E+00
HEXACHLOROBUTADIENE	3.7E+00	2.2E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	1.2E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	6.2E+00	2.1E+01	9.2E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	4.7E+00	1.0E+01	7.7E-01
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYL TERT BUTYL ETHER	1.6E+00	5.6E+00	1.8E+03
METHYLENE CHLORIDE	9.0E-01	3.2E+00	2.2E+03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00

**TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3$ m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
MOLYBDENUM	4.0E+01	4.0E+01	2.4E+02
NAPHTHALENE	3.6E+00	4.8E+00	2.4E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	3.0E+00	5.0E+00	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	7.0E+01	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	3.1E+00	7.2E+00	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	7.2E-03	2.5E-02	1.5E+02
TETRACHLOROETHYLENE	6.9E-02	2.4E-01	9.9E+01
THALLIUM	1.0E+00	1.3E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	1.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	5.0E+02	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	3.2E-01	1.1E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	2.6E-02	9.1E-02	2.8E+02
TRICHLOROETHYLENE	3.6E-02	1.3E-01	7.4E+01
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.2E+00	1.0E+01	4.9E+02
VANADIUM	1.6E+01	2.0E+02	1.9E+01

**TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Shallow Soils ( $\leq 3$ m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Shallow Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
VINYL CHLORIDE	2.0E-02	1.6E-01	1.1E+01
XYLENES	1.1E+01	1.1E+01	1.0E+02
ZINC	6.0E+02	6.0E+02	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable
<b>Notes:</b> 1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface. 2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.) 3. Assumes potential discharge of groundwater into marine or estuary surface water system. Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2. Source of groundwater ESLs: Refer to Appendix 1, Table F-1b. Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2). Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. <b>Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.</b> Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. <b>Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).</b> Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7). Refer to appendices for summary of ESL components. Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables). TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.			

**TABLE C: DEEP SOIL (>3M BGS) - WATER IS A  
CURRENT OR POTENTIAL SOURCE OF  
DRINKING WATER**

**Notes:**

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).
- ESLs for deep soils may be applicable to soils <3m below ground surface at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.5 and Section 2.10).



**TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	5.0E+00	5.0E+00	4.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	3.1E+02	3.1E+02	6.0E+00
ARSENIC	1.5E+02	1.5E+02	1.0E+01
BARIUM	2.5E+03	2.5E+03	2.0E+03
BENZENE	2.2E-01	2.2E-01	5.0E+00
BENZO(a)ANTHRACENE	1.2E+01	1.2E+01	2.7E-02
BENZO(a)PYRENE	2.4E+01	2.4E+01	1.4E-02
BENZO(b)FLUORANTHENE	4.6E+01	4.6E+01	9.2E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(k)FLUORANTHENE	3.7E+01	3.7E+01	4.0E-01
BERYLLIUM	9.8E+01	9.8E+01	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.2E-04	1.2E-04	9.5E-03
BIS(2-CHLOROISOPROPYL)ETHER	3.0E-03	3.0E-03	2.7E-01
BIS(2-ETHYLHEXYL)PHTHALATE	1.0E+02	1.0E+02	6.0E+00
BORON	4.6E+04	4.6E+04	1.6E+00
BROMODICHLOROMETHANE	3.4E-03	3.4E-03	1.8E-01
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	1.7E-01	3.4E-01	8.5E+00
CADMIUM	3.8E+02	3.8E+02	2.5E-01
CARBON TETRACHLORIDE	2.7E-02	9.6E-02	5.0E+00
CHLORDANE	1.5E+01	1.5E+01	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	2.7E-01	2.7E-01	3.9E+00
CHLOROFORM	1.8E-02	6.3E-02	6.2E+01
CHLOROMETHANE	3.2E+00	9.5E+00	1.6E+02
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	2.2E+02	2.2E+02	7.4E+01
CHROMIUM III	2.5E+03	5.0E+03	7.4E+01
CHROMIUM VI	3.1E+01	3.1E+01	1.1E+01
CHRYSENE	2.3E+01	2.3E+01	3.5E-01
COBALT	1.0E+02	1.0E+02	3.0E+00
COPPER	2.5E+03	5.0E+03	3.1E+00
CYANIDE (Free)	5.0E+02	1.0E+03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	9.9E+00	9.9E+00	9.2E-03
DIBROMO,1,2- CHLOROPROPANE,3-	4.5E-03	4.5E-03	2.0E-01
DIBROMOCHLOROMETHANE	1.1E-02	1.1E-02	1.3E-01
DIBROMOETHANE, 1,2-	4.6E-04	4.6E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

**TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	6.5E-02	2.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	4.0E-02	4.0E-02	1.5E-01
DICHLORODIPHENYLDICHLOROETHANE (DDD)	7.5E+02	7.5E+02	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.0E+03	1.1E+03	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3E+00	4.3E+00	1.0E-03
DICHLOROETHANE, 1,1-	1.9E+00	1.9E+00	4.7E+01
DICHLOROETHANE, 1,2-	1.6E-02	4.5E-02	5.0E+00
DICHLOROETHYLENE, 1,1-	1.2E+00	1.2E+00	7.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.2E+00	2.2E+00	7.0E+01
DICHLOROETHYLENE, Trans 1,2-	2.5E+00	6.7E+00	1.0E+02
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	2.1E-02	7.5E-02	5.0E+00
DICHLOROPROPENE, 1,3-	4.6E-02	4.6E-02	4.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.3E-01	7.3E-01	1.1E+02
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.3E+01
DINITROTOLUENE, 2,4-	2.5E-01	2.5E-01	3.4E+01
DIOXANE, 1,4-	3.7E-03	3.7E-03	6.1E+00
DIOXIN (2,3,7,8-TCDD)	2.0E-03	2.0E-03	3.0E-08
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+00	4.5E+00	5.0E+04
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	6.0E+01	6.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.3E-02	1.3E-02	3.6E-03
HEPTACHLOR EPOXIDE	1.4E-02	1.4E-02	3.6E-03
HEXACHLOROBENZENE	1.2E+02	1.2E+02	1.0E+00
HEXACHLOROBUTADIENE	4.3E+00	4.3E+00	8.6E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	1.6E+01	1.6E+01	4.8E+00
INDENO(1,2,3-cd)PYRENE	2.4E+01	2.4E+01	9.2E-02
LEAD	7.5E+02	7.5E+02	2.5E+00
MERCURY	2.3E+02	2.3E+02	7.7E-01
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYL ETHYL KETONE	6.4E+00	6.4E+00	7.0E+03
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	4.1E+01	4.1E+01	3.0E-03
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00
METHYLENE CHLORIDE	6.7E-02	6.7E-02	4.3E+00
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00

**TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
MOLYBDENUM	2.5E+03	3.9E+03	1.8E+02
NAPHTHALENE	1.2E+00	1.2E+00	6.2E+00
NICKEL	2.5E+03	5.0E+03	8.2E+00
PENTACHLOROPHENOL	5.3E+00	5.3E+00	1.0E+00
PERCHLORATE	7.0E-03	7.0E-03	3.7E+00
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	6.3E+00	6.3E+00	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	2.5E+03	3.9E+03	5.0E+00
SILVER	2.5E+03	3.9E+03	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	2.3E-02	2.3E-02	3.7E+00
TETRACHLOROETHANE, 1,1,1,2-	7.6E-03	7.6E-03	4.3E-01
TETRACHLOROETHANE, 1,1,2,2-	9.9E-04	9.9E-04	5.6E-02
TETRACHLOROETHYLENE	6.9E-02	2.4E-01	5.0E+00
THALLIUM	5.1E+01	5.1E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	1.0E+03	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	3.2E-01	1.1E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	2.6E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	3.6E-02	1.3E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.2E+00	1.2E+00	3.7E+00
VANADIUM	7.7E+02	7.7E+02	1.9E+01

**TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
VINYL CHLORIDE	2.0E-02	1.6E-01	2.0E+00
XYLENES	2.3E+00	2.3E+00	2.0E+01
ZINC	2.5E+03	5.0E+03	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable
<b>Notes:</b> 1. Deep soils defined as soils greater than 3 meters (approximately 10 feet) below ground surface. 2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.) 3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system. Source of soil ESLs: Refer to Appendix 1, Tables C-1 and C-2. Source of groundwater ESLs: Refer to Appendix 1, Table F-1a. Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2). Soil ESLs intended to address human health, groundwater protection and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios. <b>Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.</b> Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. <b>Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).</b> Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7). Refer to appendices for summary of ESL components. Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables). TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.			

**TABLE D: DEEP SOIL (>3M BGS) - WATER IS NOT A  
CURRENT OR POTENTIAL SOURCE OF  
DRINKING WATER**

**Notes:**

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.4).
- ESLs for deep soils may be applicable to soils <3m below ground surface at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.5 and Section 2.10).



**TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	5.0E+00	5.0E+00	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	3.1E+02	3.1E+02	3.0E+01
ARSENIC	1.5E+02	1.5E+02	3.6E+01
BARIUM	2.5E+03	2.5E+03	2.0E+03
BENZENE	5.3E-01	1.9E+00	4.6E+01
BENZO(a)ANTHRACENE	1.2E+01	1.2E+01	2.7E-02
BENZO(a)PYRENE	2.4E+01	2.4E+01	1.4E-02
BENZO(b)FLUORANTHENE	4.6E+01	4.6E+01	9.2E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(k)FLUORANTHENE	3.7E+01	3.7E+01	4.0E-01
BERYLLIUM	9.8E+01	9.8E+01	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	6.7E-03	2.8E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	5.3E+02	5.3E+02	3.2E+01
BORON	4.6E+04	4.6E+04	1.6E+00
BROMODICHLOROMETHANE	2.3E-02	8.2E-02	2.7E+02
BROMOFORM	6.9E+01	6.9E+01	3.2E+03
BROMOMETHANE	1.7E-01	5.1E-01	1.6E+02
CADMIUM	3.8E+02	3.8E+02	2.5E-01
CARBON TETRACHLORIDE	2.7E-02	9.6E-02	9.8E+00
CHLORDANE	1.5E+01	1.5E+01	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	2.7E-01	2.7E-01	3.9E+00
CHLOROFORM	1.8E-02	6.3E-02	6.2E+01
CHLOROMETHANE	3.2E+00	9.5E+00	1.9E+03
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	2.2E+02	2.2E+02	7.4E+01
CHROMIUM III	2.5E+03	5.0E+03	7.4E+01
CHROMIUM VI	3.1E+01	3.1E+01	1.1E+01
CHRYSENE	2.3E+01	2.3E+01	3.5E-01
COBALT	1.0E+02	1.0E+02	3.0E+00
COPPER	2.5E+03	5.0E+03	3.1E+00
CYANIDE (Free)	5.0E+02	1.0E+03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	2.4E+01	2.4E+01	2.5E-01
DIBROMO,1,2- CHLOROPROPANE,3-	4.5E-03	4.5E-03	2.0E-01
DIBROMOCHLOROMETHANE	1.7E-02	2.2E-02	1.6E+02
DIBROMOETHANE, 1,2-	7.2E-04	2.5E-03	1.6E+01
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01

**TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	6.5E-02	2.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	6.6E+01	6.6E+01	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	7.5E+02	7.5E+02	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.0E+03	1.1E+03	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3E+00	4.3E+00	1.0E-03
DICHLOROETHANE, 1,1-	1.9E+00	1.9E+00	4.7E+01
DICHLOROETHANE, 1,2-	1.6E-02	5.6E-02	1.3E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.2E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	2.5E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	2.1E-02	7.5E-02	1.0E+02
DICHLOROPROPENE, 1,3-	1.0E-01	3.6E-01	1.2E+02
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.3E-01	7.3E-01	1.1E+02
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
DIOXANE, 1,4-	3.0E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	2.0E-03	2.0E-03	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+00	4.5E+00	5.0E+04
ETHYLBENZENE	3.2E+01	3.2E+01	2.9E+02
FLUORANTHENE	6.0E+01	6.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.3E-02	1.3E-02	3.6E-03
HEPTACHLOR EPOXIDE	1.4E-02	1.4E-02	3.6E-03
HEXACHLOROBENZENE	1.2E+02	1.2E+02	3.7E+00
HEXACHLOROBUTADIENE	2.3E+01	2.3E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	4.1E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	2.4E+01	2.4E+01	9.2E-02
LEAD	7.5E+02	7.5E+02	2.5E+00
MERCURY	2.3E+02	2.3E+02	7.7E-01
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	4.1E+01	4.1E+01	3.0E-03
METHYL TERT BUTYL ETHER	1.6E+00	5.6E+00	1.8E+03
METHYLENE CHLORIDE	9.0E-01	3.2E+00	2.2E+03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00

**TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
MOLYBDENUM	2.5E+03	3.9E+03	2.4E+02
NAPHTHALENE	3.6E+00	4.8E+00	2.4E+01
NICKEL	2.5E+03	5.0E+03	8.2E+00
PENTACHLOROPHENOL	4.2E+01	4.2E+01	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	6.3E+00	6.3E+00	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	2.5E+03	3.9E+03	5.0E+00
SILVER	2.5E+03	3.9E+03	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	1.1E+02	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	1.6E+01	1.6E+01	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	7.2E-03	2.5E-02	1.5E+02
TETRACHLOROETHYLENE	6.9E-02	2.4E-01	9.9E+01
THALLIUM	5.1E+01	5.1E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	4.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	5.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	1.0E+03	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	3.2E-01	1.1E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	2.6E-02	9.1E-02	2.8E+02
TRICHLOROETHYLENE	3.6E-02	1.3E-01	7.4E+01
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	4.0E+01	4.0E+01	4.9E+02
VANADIUM	7.7E+02	7.7E+02	1.9E+01

**TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Deep Soils (>3m bgs)**  
**Groundwater IS NOT a Current or Potential Source of Drinking Water**

CHEMICAL PARAMETER	<sup>1</sup> Deep Soil		<sup>3</sup> Groundwater (ug/L)
	<sup>2</sup> Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
VINYL CHLORIDE	2.0E-02	1.6E-01	1.1E+01
XYLENES	1.1E+01	1.1E+01	1.0E+02
ZINC	2.5E+03	5.0E+03	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable
<b>Notes:</b> 1. Deep soils defined as soils greater than 3 meters (approximately 10 feet) below ground surface. 2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.) 3. Assumes potential discharge of groundwater into marine or estuary surface water system. Source of soil ESLs: Refer to Appendix 1, Tables D-1 and D-2. Source of groundwater ESLs: Refer to Appendix 1, Table F-1b. Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2). Soil ESLs intended to address human health, groundwater protection and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios. <b>Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.</b> Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. <b>Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).</b> Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7). Refer to appendices for summary of ESL components. Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables). TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.			

## **TABLE E: SHALLOW SOIL GAS AND INDOOR AIR**

**Notes:**

- Shallow soil gas intended to reflect soil gas zero to five feet below ground surface or the foundation of a building. Collection of soil gas data from depths <3 feet below ground surface in open areas is generally not practical (see Section 2.6).



**TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Indoor Air and Soil Gas**  
**(Vapor Intrusion Concerns)**

CHEMICAL PARAMETER	INDOOR AIR SCREENING LEVELS		<sup>2</sup> SHALLOW SOIL GAS SCREENING LEVELS	
	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )
ACENAPHTHENE	4.4E+01	6.1E+01	4.4E+04	1.2E+05
ACENAPHTHYLENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
ACETONE	6.6E+02	9.2E+02	6.6E+05	1.8E+06
ALDRIN				
ANTHRACENE	2.2E+02	3.1E+02	2.2E+05	6.1E+05
ANTIMONY				
ARSENIC				
BARIUM				
BENZENE	2.5E-01	5.3E-01	2.5E+02	1.1E+03
BENZO(a)ANTHRACENE				
BENZO(a)PYRENE				
BENZO(b)FLUORANTHENE				
BENZO(g,h,i)PERYLENE				
BENZO(k)FLUORANTHENE				
BERYLLIUM				
BIPHENYL, 1,1-	3.7E+01	5.1E+01	3.7E+04	1.0E+05
BIS(2-CHLOROETHYL)ETHER	5.6E-03	1.2E-02	5.6E+00	2.4E+01
BIS(2-CHLOROISOPROPYL)ETHER	1.9E-01	4.1E-01	1.9E+02	8.2E+02
BIS(2-ETHYLHEXYL)PHTHALATE				
BORON				
BROMODICHLOROMETHANE	1.1E-01	2.3E-01	1.1E+02	4.6E+02
BROMOFORM				
BROMOMETHANE	1.0E+00	1.4E+00	1.0E+03	2.9E+03
CADMIUM				
CARBON TETRACHLORIDE	1.3E-01	2.7E-01	1.3E+02	5.4E+02
CHLORDANE				
CHLOROANILINE, p-				
CHLOROBENZENE	1.2E+01	1.7E+01	1.2E+04	3.5E+04
CHLOROETHANE	2.3E+00	4.9E+00	2.3E+03	9.9E+03
CHLOROFORM	8.3E-02	1.8E-01	8.3E+01	3.5E+02
CHLOROMETHANE	1.9E+01	2.7E+01	1.9E+04	5.3E+04
CHLOROPHENOL, 2-	3.7E+00	5.1E+00	3.7E+03	1.0E+04
CHROMIUM (Total)				
CHROMIUM III				
CHROMIUM VI				
CHRYSENE				
COBALT				
COPPER				
CYANIDE (Free)				
DIBENZO(a,h)ANTHTRACENE				
DIBROMO,1,2- CHLOROPROPANE,3-	4.2E-02	5.8E-02	4.2E+01	1.2E+02
DIBROMOCHLOROMETHANE	8.0E-02	1.7E-01	8.0E+01	3.4E+02
DIBROMOETHANE, 1,2-	3.4E-03	7.2E-03	3.4E+00	1.4E+01
DICHLOROBENZENE, 1,2-	4.2E+01	5.8E+01	4.2E+04	1.2E+05

**TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Indoor Air and Soil Gas**  
**(Vapor Intrusion Concerns)**

CHEMICAL PARAMETER	INDOOR AIR SCREENING LEVELS		<sup>2</sup> SHALLOW SOIL GAS SCREENING LEVELS	
	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )
DICHLOROBENZENE, 1,3-	2.2E+01	3.1E+01	2.2E+04	6.1E+04
DICHLOROBENZENE, 1,4-	3.1E-01	6.5E-01	3.1E+02	1.3E+03
DICHLOROBENZIDINE, 3,3-				
DICHLORODIPHENYLDICHLOROETHANE (DDD)				
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)				
DICHLORODIPHENYLTRICHLOROETHANE (DDT)				
DICHLOROETHANE, 1,1-	1.0E+02	1.4E+02	1.0E+05	2.9E+05
DICHLOROETHANE, 1,2-	7.4E-02	1.6E-01	7.4E+01	3.1E+02
DICHLOROETHYLENE, 1,1-	4.2E+01	5.8E+01	4.2E+04	1.2E+05
DICHLOROETHYLENE, Cis 1,2-	7.3E+00	1.0E+01	7.3E+03	2.0E+04
DICHLOROETHYLENE, Trans 1,2-	1.5E+01	2.0E+01	1.5E+04	4.1E+04
DICHLOROPHENOL, 2,4-				
DICHLOROPROPANE, 1,2-	9.9E-02	2.1E-01	9.9E+01	4.2E+02
DICHLOROPROPENE, 1,3-	4.8E-01	1.0E+00	4.8E+02	2.0E+03
DIELDRIN				
DIETHYLPHTHALATE				
DIMETHYLPHENOL, 2,4-	1.5E+01	2.0E+01	1.5E+04	4.1E+04
DIMETHYLPHTHALATE				
DINITROPHENOL, 2,4-				
DINITROTOLUENE, 2,4-				
DIOXANE, 1,4-				
DIOXIN (2,3,7,8-TCDD)				
ENDOSULFAN				
ENDRIN				
ETHANOL	1.9E+04	1.9E+04	1.9E+07	3.8E+07
ETHYLBENZENE	2.1E+02	3.0E+02	2.1E+05	5.9E+05
FLUORANTHENE				
FLUORENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
HEPTACHLOR				
HEPTACHLOR EPOXIDE				
HEXACHLOROBENZENE				
HEXACHLOROBUTADIENE				
HEXACHLOROCYCLOHEXANE (gamma) LINDANE				
HEXACHLOROETHANE				
INDENO(1,2,3-cd)PYRENE				
LEAD				
MERCURY	6.2E-02	8.7E-02	6.2E+01	1.7E+02
METHOXYCHLOR				
METHYL ETHYL KETONE	1.0E+03	1.4E+03	1.0E+06	2.9E+06
METHYL ISOBUTYL KETONE	6.3E+02	8.8E+02	6.3E+05	1.8E+06
METHYL MERCURY				
METHYL TERT BUTYL ETHER	7.4E+00	1.6E+01	7.4E+03	3.1E+04
METHYLENE CHLORIDE	4.2E+00	8.9E+00	4.2E+03	1.8E+04
METHYLNAPHTHALENE (total 1- & 2-)	2.9E+01	4.1E+01	2.9E+04	8.2E+04

**TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Indoor Air and Soil Gas**  
**(Vapor Intrusion Concerns)**

CHEMICAL PARAMETER	INDOOR AIR SCREENING LEVELS		<sup>2</sup> SHALLOW SOIL GAS SCREENING LEVELS	
	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )
MOLYBDENUM				
NAPHTHALENE	6.3E-01	8.8E-01	6.3E+02	1.8E+03
NICKEL				
PENTACHLOROPHENOL				
PERCHLORATE				
PHENANTHRENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
PHENOL				
POLYCHLORINATED BIPHENYLS (PCBs)				
PYRENE	2.2E+01	3.1E+01	2.2E+04	6.1E+04
SELENIUM				
SILVER				
STYRENE	2.1E+02	3.0E+02	2.1E+05	5.9E+05
tert-BUTYL ALCOHOL	2.2E+00	4.8E+00	2.2E+03	9.5E+03
TETRACHLOROETHANE, 1,1,1,2-	2.6E-01	5.5E-01	2.6E+02	1.1E+03
TETRACHLOROETHANE, 1,1,2,2-	3.4E-02	7.2E-02	3.4E+01	1.4E+02
TETRACHLOROETHYLENE	3.2E-01	6.8E-01	3.2E+02	1.4E+03
THALLIUM				
TOLUENE	8.0E+01	1.1E+02	8.0E+04	2.2E+05
TOXAPHENE				
TPH (gasolines)	1.0E+01	1.4E+01	1.0E+04	2.9E+04
TPH (middle distillates)	1.0E+01	1.4E+01	1.0E+04	2.9E+04
TPH (residual fuels)				
TRICHLOROBENZENE, 1,2,4-	7.3E-01	1.0E+00	7.3E+02	2.0E+03
TRICHLOROETHANE, 1,1,1-	4.6E+02	6.4E+02	4.6E+05	1.3E+06
TRICHLOROETHANE, 1,1,2-	1.2E-01	2.6E-01	1.2E+02	5.1E+02
TRICHLOROETHYLENE	1.7E-02	3.6E-02	1.7E+01	7.2E+01
TRICHLOROPHENOL, 2,4,5-	7.3E+01	1.0E+02	7.3E+04	2.0E+05
TRICHLOROPHENOL, 2,4,6-				
VANADIUM				
VINYL CHLORIDE	2.2E-01	4.6E-01	2.2E+02	9.2E+02
XYLENES	2.1E+01	3.0E+01	2.1E+04	5.9E+04
ZINC				

**TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Indoor Air and Soil Gas**  
**(Vapor Intrusion Concerns)**

	INDOOR AIR SCREENING LEVELS		<sup>2</sup> SHALLOW SOIL GAS SCREENING LEVELS	
	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )	<sup>1</sup> Residential Land Use (ug/m <sup>3</sup> )	Commercial/ Industrial Land Use Only (ug/m <sup>3</sup> )
<b>CHEMICAL PARAMETER</b>				
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable	not applicable
<b>Notes:</b> 1. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.) 2. Soil Gas: Screening levels based on soil gas data collected within 1.5 meters (five feet) below a building foundation or the ground surface. Intended for evaluation of potential indoor-air impacts. <b>Screening levels also apply to areas over both contaminated soil and contaminated groundwater.</b> Source of soil ESLs: Refer to Tables E-2 and E-3 in Appendix 1. TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.				

## **TABLE F: SURFACE WATER**



**TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Surface Water Bodies**

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	<sup>1</sup> Freshwater (ug/L)	<sup>2</sup> Marine (ug/L)	<sup>3</sup> Estuarine (ug/L)
ACENAPHTHENE	2.0E+01	2.0E+01	2.0E+01
ACENAPHTHYLENE	3.0E+01	3.0E+01	3.0E+01
ACETONE	1.5E+03	1.5E+03	1.5E+03
ALDRIN	5.0E-05	5.0E-05	5.0E-05
ANTHRACENE	7.3E-01	7.3E-01	7.3E-01
ANTIMONY	6.0E+00	5.0E+02	3.0E+01
ARSENIC	1.4E-01	1.4E-01	1.4E-01
BARIUM	2.0E+03	2.0E+03	2.0E+03
BENZENE	5.0E+00	5.1E+01	4.6E+01
BENZO(a)ANTHRACENE	1.8E-02	1.8E-02	1.8E-02
BENZO(a)PYRENE	1.4E-02	1.4E-02	1.4E-02
BENZO(b)FLUORANTHENE	1.8E-02	1.8E-02	1.8E-02
BENZO(g,h,i)PERYLENE	1.0E-01	1.0E-01	1.0E-01
BENZO(k)FLUORANTHENE	1.8E-02	1.8E-02	1.8E-02
BERYLLIUM	2.7E+00	2.7E+00	2.7E+00
BIPHENYL, 1,1-	5.0E-01	5.0E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	9.5E-03	5.3E-01	5.3E-01
BIS(2-CHLOROISOPROPYL)ETHER	2.7E-01	6.1E+01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	2.2E+00	2.2E+00	2.2E+00
BORON	1.6E+00	1.6E+00	1.6E+00
BROMODICHLOROMETHANE	1.8E-01	3.2E+03	3.2E+03
BROMOFORM	1.0E+02	1.4E+02	1.4E+02
BROMOMETHANE	8.5E+00	1.5E+03	1.6E+02
CADMIUM	2.5E-01	8.8E+00	2.5E-01
CARBON TETRACHLORIDE	1.6E+00	1.6E+00	1.6E+00
CHLORDANE	8.1E-04	8.1E-04	8.1E-04
CHLOROANILINE, p-	5.0E+00	5.0E+00	5.0E+00
CHLOROBENZENE	2.5E+01	5.0E+01	2.5E+01
CHLOROETHANE	3.9E+00	3.9E+00	3.9E+00
CHLOROFORM	1.0E+02	4.7E+02	4.7E+02
CHLOROMETHANE	1.6E+02	3.2E+03	3.2E+03
CHLOROPHENOL, 2-	1.8E-01	1.8E-01	1.8E-01
CHROMIUM (Total)	7.4E+01	7.4E+01	7.4E+01
CHROMIUM III	7.4E+01	7.4E+01	7.4E+01
CHROMIUM VI	1.1E+01	5.0E+01	1.1E+01
CHRYSENE	1.8E-02	1.8E-02	1.8E-02
COBALT	3.0E+00	3.0E+00	3.0E+00
COPPER	9.0E+00	3.1E+00	3.1E+00
CYANIDE (Free)	5.2E+00	1.0E+00	1.0E+00
DIBENZO(a,h)ANTHTRACENE	9.2E-03	1.8E-02	1.8E-02
DIBROMO,1,2- CHLOROPROPANE,3-	2.0E-01	2.0E-01	2.0E-01
DIBROMOCHLOROMETHANE	1.3E-01	1.3E+01	1.3E+01
DIBROMOETHANE, 1,2-	5.0E-02	1.4E+03	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+01	1.0E+01	1.0E+01
DICHLOROBENZENE, 1,3-	7.1E+01	6.5E+01	6.5E+01
DICHLOROBENZENE, 1,4-	5.0E+00	1.1E+01	1.1E+01
DICHLOROBENZIDINE, 3,3-	2.8E-02	2.8E-02	2.8E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	3.1E-04	3.1E-04	3.1E-04
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	2.2E-04	2.2E-04	2.2E-04
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	2.2E-04	2.2E-04	2.2E-04
DICHLOROETHANE, 1,1-	4.7E+01	4.7E+01	4.7E+01

**TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Surface Water Bodies**

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	<sup>1</sup> Freshwater (ug/L)	<sup>2</sup> Marine (ug/L)	<sup>3</sup> Estuarine (ug/L)
DICHLOROETHANE, 1,2-	5.0E+00	3.7E+01	3.7E+01
DICHLOROETHYLENE, 1,1-	3.2E+00	3.2E+00	3.2E+00
DICHLOROETHYLENE, Cis 1,2-	7.0E+01	5.9E+02	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	1.0E+02	2.6E+02	2.6E+02
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.0E+00	1.0E+01	1.0E+01
DICHLOROPROPENE, 1,3-	4.0E-01	1.2E+02	1.2E+02
DIELDRIN	5.4E-05	5.4E-05	5.4E-05
DIETHYLPHTHALATE	1.5E+00	1.7E+00	1.5E+00
DIMETHYLPHENOL, 2,4-	4.0E+02	1.1E+02	1.1E+02
DIMETHYLPHTHALATE	1.5E+00	1.7E+00	1.5E+00
DINITROPHENOL, 2,4-	7.3E+01	7.5E+01	7.5E+01
DINITROTOLUENE, 2,4-	3.4E+00	3.4E+00	3.4E+00
DIOXANE, 1,4-	6.1E+00	5.0E+04	5.0E+04
DIOXIN (2,3,7,8-TCDD)	5.1E-09	5.1E-09	5.1E-09
ENDOSULFAN	5.6E-02	8.7E-03	8.7E-03
ENDRIN	3.6E-02	2.3E-03	2.3E-03
ETHANOL	5.0E+04	5.0E+04	5.0E+04
ETHYLBENZENE	3.0E+01	3.0E+01	3.0E+01
FLUORANTHENE	8.1E+00	8.0E+00	8.0E+00
FLUORENE	3.9E+00	3.9E+00	3.9E+00
HEPTACHLOR	7.9E-05	7.9E-05	7.9E-05
HEPTACHLOR EPOXIDE	3.9E-05	3.9E-05	3.9E-05
HEXACHLOROBENZENE	2.9E-04	2.9E-04	2.9E-04
HEXACHLOROBUTADIENE	8.6E-01	4.7E+00	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	6.3E-02	6.3E-02	6.3E-02
HEXACHLOROETHANE	3.3E+00	3.3E+00	3.3E+00
INDENO(1,2,3-cd)PYRENE	1.8E-02	1.8E-02	1.8E-02
LEAD	2.5E+00	8.1E+00	2.5E+00
MERCURY	3.0E-01	3.0E-01	3.0E-01
METHOXYCHLOR	1.9E-02	1.9E-02	1.9E-02
METHYL ETHYL KETONE	7.0E+03	8.4E+03	8.4E+03
METHYL ISOBUTYL KETONE	1.7E+02	1.7E+02	1.7E+02
METHYL MERCURY	3.0E-03	3.0E-03	3.0E-03
METHYL TERT BUTYL ETHER	5.0E+00	1.8E+02	1.8E+02
METHYLENE CHLORIDE	4.3E+00	5.9E+02	5.9E+02
METHYLNAPHTHALENE (total 1- & 2-)	2.1E+00	2.1E+00	2.1E+00
MOLYBDENUM	1.8E+02	2.4E+02	2.4E+02
NAPHTHALENE	6.2E+00	2.1E+01	2.1E+01
NICKEL	5.2E+01	8.2E+00	8.2E+00
PENTACHLOROPHENOL	1.0E+00	3.0E+00	3.0E+00
PERCHLORATE	3.7E+00	6.0E+02	6.0E+02
PHENANTHRENE	6.3E+00	4.6E+00	4.6E+00
PHENOL	5.0E+00	1.3E+03	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	6.4E-05	6.4E-05	6.4E-05
PYRENE	2.0E+00	2.0E+00	2.0E+00
SELENIUM	5.0E+00	7.1E+01	5.0E+00
SILVER	3.2E-01	1.9E-01	1.9E-01
STYRENE	1.0E+01	1.1E+01	1.1E+01
tert-BUTYL ALCOHOL	3.7E+00	1.8E+04	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	4.3E-01	9.3E+02	9.3E+02

**TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)**  
**Surface Water Bodies**

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	<sup>1</sup> Freshwater (ug/L)	<sup>2</sup> Marine (ug/L)	<sup>3</sup> Estuarine (ug/L)
TETRACHLOROETHANE, 1,1,2,2-	5.6E-02	4.0E+00	4.0E+00
TETRACHLOROETHYLENE	3.3E+00	3.3E+00	3.3E+00
THALLIUM	2.0E+00	6.3E+00	6.3E+00
TOLUENE	4.0E+01	4.0E+01	4.0E+01
TOXAPHENE	2.0E-04	2.0E-04	2.0E-04
TPH (gasolines)	1.0E+02	3.7E+03	5.0E+02
TPH (middle distillates)	1.0E+02	6.4E+02	6.4E+02
TPH (residual fuels)	1.0E+02	6.4E+02	6.4E+02
TRICHLOROBENZENE, 1,2,4-	2.5E+01	6.5E+01	2.5E+01
TRICHLOROETHANE, 1,1,1-	6.2E+01	6.2E+01	6.2E+01
TRICHLOROETHANE, 1,1,2-	5.0E+00	1.6E+01	1.6E+01
TRICHLOROETHYLENE	5.0E+00	3.0E+01	3.0E+01
TRICHLOROPHENOL, 2,4,5-	6.3E+01	1.1E+01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	3.7E+00	1.0E+02	1.0E+02
VANADIUM	1.9E+01	1.9E+01	1.9E+01
VINYL CHLORIDE	2.0E+00	5.3E+02	5.3E+02
XYLENES	2.0E+01	1.0E+02	1.0E+02
ZINC	1.2E+02	8.1E+01	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable
<b>Notes:</b> 1. Source of Freshwater ESLs: Refer to Appendix 1, Table F-2a 2. Source of Marine ESLs: Refer to Appendix 1, Table F-2b. 3. Source of Estuarine ESLs: Refer to Appendix 1, Table F-2c. Surface water screening levels lowest of drinking water goal (freshwater only), chronic aquatic habitat goal, goal to address bioaccumulation in aquatic organisms and subsequent consumption by humans, and general nuisance goal (odors, etc.). Refer to Section 2.7 of text for discussion. Estuarine screening levels lowest of freshwater and marine screening levels. Water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables). TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Section 2.2 and Appendix 1, Chapter 5.			

